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The Call to Engineers

FOR many years I have preached the doctrine that the future of this country depends to a large extent upon engineers. I deplored the fact that after the last war the engineering trades which had done so much to bring it to success—ful conclusion, was cast off like an old boot by the Government, which destroyed the incentive for young men to serve apprenticeships. Disarmament was the order of the day.

Now it was a voice crying in the wilderness, but I cannot refrain from pointing out now how right I was. Young men found it comparatively easy at the age of fifteen to obtain a blind alley occupation at 30s. or so a week, and so they deserted the chance of becoming an apprentice at a much smaller financial reward but with a much richer accretion of experience.

Over twenty years have passed since the war, but the building trades will be working at top pressure because of the boom which will inevitably follow the war. We are concentrating every nerve upon winning it, and thus we must neglect the manufacture of things not essential to its prosecution. A young man may therefore consider the prospects of engineering as a career as being particularly bright. This is especially so when we remember that during the past quarter of a century many new branches of engineering have sprung up as a result of the introduction of new materials, such as plastics, and new methods of manufacture.

Aptitude

THERE should be excellent opportunities for the individual with the necessary aptitude. Aptitude is, of course, required in engineering. An interest of mechanical things is one of the first requirements. Study of such subjects as mathematics, machine drawing, machine design, manufacturing processes, and machine-shop practice are necessary essentials. Thus, whilst the practical training is being acquired evening classes and/or postal tuition will lift the individual beyond the ranks of the practician.

The practical side of engineering offers equally good prospects to the man skilled in the use of tools, both hand and machine. Not every individual wishes to become a designer or a draughtsman. The skilled turner, the toolmaker, the man able to do all branches of milling, precision grinding, planing and shaping, will be in great demand for the next ten years.

The country to-day realises only too well that it must depend for the successful issue of the war upon the soldier and the engineer. I therefore invite those of my readers now in process of picking a career to give careful consideration of the prospects I have outlined.

FAIR COMMENT

By the Editor

The practical mechanics over the country are doing their best to supply the demands. It takes a number of years to train an engineer, but I have no doubt that these training centres will be able to supply men for some of the lesser skilled occupations.

Now we have the lessons of the last war upon which to go, and the young man not of military age who is now at that halcyon period of life when he leaves school behind him, and is upon the threshold of his career, may find it profitable to reflect that this country will not, as it did the last time, desert engineering. In any case, for many years to come the engineering and the building trades will be working at top pressure because of the boom which will inevitably follow the war. We are concentrating every nerve upon winning it, and thus we must neglect the manufacture of things not essential to its prosecution. A young man may therefore consider the prospects of engineering as a career as being particularly bright. This is especially so when we remember that during the past quarter of a century many new branches of engineering have sprung up as a result of the introduction of new materials, such as plastics, and new methods of manufacture.
The Principles of

Interesting Particulars

Lifebelts of

descended to earth safely by it after throwing himself from a tall tower. Apart from the fact that this parachute consisted of a rectangular piece of canvas attached to a wide frame, we have no further particulars of its origin or use.

Towards the end of the 18th century, soon after the invention of the gas-filled balloon, a number of different parachutists made their appearance. The famous aeronaut, Blanchard, for instance, experimented by casting animals out of balloons which had reached great heights, each animal having a parachute device attached to it. And finally, we read, Blanchard pleaded up sufficient courage to throw himself out of his balloon, and to rely for his safe descent upon a crude parachute device of his own construction.

The Pioneer, Garnerin

The first really successful parachutist of all history was a certain Andre Jacques Garnerin, who, on October 22, 1797, rose from a park at Monceau, near Paris, on a parachute attached to a balloon. At a height of 2,000 feet, he cut the cord which attached his parachute to the balloon. The balloon instantly shot upwards, and Garnerin, equally as suddenly, shot downwards. This intrepid pioneer, however, despite the fact that he was made very dizzy and sick by his violent pendulum-like movements as he sailed downwards through the air, landed safely, and was given a great reception by the admiring spectators who had witnessed his historical performance.

It is interesting to record Garnerin as being the first parachutist to descend upon English soil, a feat which he accomplished on September 21, 1802, in the presence of a large concourse of people.

During the 19th century, parachute descents were, for the most part, made in connection with fairs and outdoor displays, and it has only been since the introduction of the aeroplane that the parachute has come in for the amount of scientific attention which it obviously has richly deserved.

Most of the early parachutes were of the now familiar "umbrella" type, which, so far as European history is concerned, originated in the theoretical "dome" of Leonardo da Vinci at the beginning of the 16th century. Such parachutes, however, had two great faults—that of "pumping," or violently oscillating in a vertically upward and downward direction, and, also, that of "swinging," the unfortunate parachutist being compelled to undergo a rapid to-and-fro swinging movement as he descended to the ground.

By careful attention to design, these great drawbacks have now totally disappeared from the characteristics of the modern parachute, which, in reasonably good weather, descends to the ground, after having once opened out, with almost unbelievable sweetness and steadiness.

The early parachutes, however, oscillated violently as a result of their tendency to turn upside down. Modern parachutes invariably have a small aperture at their apex which enables the air imprisoned in

For a century or more air travellers and explorers have toyed with practical parachutes of one description or another, but it is only since the beginning of the Great War that the parachute as an almost hundred per cent. safety device for emergency use in the air has been forthcoming.

It was Leonardo da Vinci, that fertile and many-sided Italian genius, who first seems to have been struck with the idea of the parachute in what we may relatively call modern times, although it is very probable that this air safety-device was known, at least in principle, by the ancient Chinese technicians. Says the famous Leonardo, writing about the year 1600, "If a man have a dome of fabric above him and suspend himself thereby, he shall be able to make safe descent to the ground from a height."

But the versatile da Vinci, although he undoubtedly mentioned that which we now term the parachute in his writings, never seems to have had the courage of his convictions in this particular instance, for he did not put into practice his notion of the parachute, preferring, it would appear, to remain with a vague theorising in this direction.

The First Parachute

The first parachute ever made is held to have been constructed by another Italian, one Pante Veranzio, sometime in the 18th century, and Veranzio is said to have
Concerning the Modern Parachutes

The technique of the parachute descent is not a difficult one for anyone to get into, although, naturally enough, the first descent (provided it is not made under circumstances of dire emergency) calls for the presence of a certain amount of confidence and courage. Having the parachute pack firmly strapped in position, the user either jumps or steps into space from the travelling 'plane. After (but not before) the decisive jump or step into space has been made, the parachutist pulls the substantial metal ring attached to the rip cord. In practice, this rip cord release is normally made within a second or two of leaving the 'plane. Within about one and a half seconds of this action being carried out, the parachute opens fully, allowing the user of it to descend gently and steadily to the earth's surface. As a precaution against bad weather, when, under such conditions, the parachutist, after making contact with the ground, might possibly be picked up again by a gust of wind and dragged violently along the ground, a quick-release device is usually incorporated into the parachute harness, whereby the parachutist, having safely reached the ground, may almost instantly detach himself from the main body of the parachute, leaving the latter free to be blown away by the wind.

There is no mystery concerning the almost incredible safety of the modern parachute. Based on the original Irvin "free" parachute, the modern parachute, or "air-lifebelt," as it has come to be called, contains within its compacted assembly a small or auxiliary parachute which is released immediately upon the pulling of the rip cord of the pack. This auxiliary or pilot parachute shoots out and, instantly unfolding itself, serves to pull out the main body of the parachute, from whose edges are suspended the rigging lines attached to the man-carrying harness of the device.

Irvin Type of Parachute

The average Irvin type of parachute has an opened-out diameter of about 24 feet, and it weighs, with its harness, some 18 lbs. Its rate of falling (with a passenger of about 12 stones) is of the order of 16 feet per second. Military-type parachutes are often smaller and they permit of more rapid descents, which, in drastic circumstances, are naturally essential. Usually, the parachutist of average weight comes to earth without feeling any more shock than that experienced after jumping off a six-feet wall.

Provided that the rip cord is pulled a second or two after leaving the 'plane, the average "dead drop" of the parachute user is only about 60 to 80 feet before the parachute leaves the latter free to be blown away by the wind.

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Chute descent is one in which practised parachutists can become exceedingly expert. This "delayed drop," of course, consists of stepping or jumping overboard from an aeroplane at a great altitude, and in purposely refraining from pulling the rip cord of the parachute until a "dead" fall of one, two or even more thousand feet have been made.

The fact that a man can fall freely through space for several thousand feet without experiencing breathlessness or impairment of mental faculties, successfully demolished once and for all the very common and age-old theory that the downwards rush from a height deprives a falling individual of his senses. After a "dead-dropping" parachutist has fallen about 1,600 feet under the earth's atmosphere a "Curtis," weighing some 1,800 lbs.

Needless to say, there are great difficulties to be overcome before this principle of providing for the safe descent of an aeroplane in an emergency by means of a parachute device can be made essentially practicable, such difficulties being mainly concerned with the enormous size of the parachute required to support such a great weight. Nevertheless, it does seem possible that some modification of the parachute principle may ultimately be forthcoming whereby parachutes of reasonable dimensions may be made capable of supporting very greatly increased loads and, also, given a certain degree of steering power which they nowadays, of course, decidedly lack.

A "powered parachute" embodying a small motor and a steering device is by no means a too optimistic dream of the future. Nor, again, is one which might be available for long-distance travel. But at the present time, however, the parachute, as its name (derived from the French) implies, must remain a device whereby we "prepare to fall." As such, this "airman's lifebelt" has saved thousands of lives, and has rendered to air-travellers the possibility of an emergency descent downwards through space rather an interesting one, than an otherwise inevitably fatal headlong hurl to earth.

Making an Anemometer

A n anemometer, or wind measurer, is easily made, but at the same time is one of the most fascinating pieces of apparatus. Four semi-circular cups form a kind of horizontal windmill which spins slowly or rapidly, according to the velocity of the wind. By means of a worm and pinion gear a pointer moves over a graduated scale, from which can easily be found the speed of the wind in miles per hour.

The cups are beaten out of circular pieces of sheet copper, exactly 4.71 in. in diameter and 1 in. thick, and thus 1/100 of a mile. If you do metal work this is a simple task. If not, you can get them made quite cheaply.

The Box

This is about 6 in. long, 3 in. deep and 4 in. high. It should be firmly screwed together. A sheet of glass forms the front, through which the dial is read. The bearing in the top of the box is formed by screwing a piece of sheet brass on and boring a hole just large enough to allow the worm to revolve freely. Also the hole in the wood should be a little larger to allow perfect clearance.

If made exactly to these dimensions, fifty-six revolutions of the cups, i.e. one revolution of the pinion and pointer, equal 1/10 of a mile. Each division on the dial is thus 1/100 of a mile.

When the wind is blowing, watch the pointer and note carefully how many divisions it passes in one minute, or five seconds. Then multiply this number by 10/100 in one minute. This means a speed of 1/100 miles in one minute or six miles per hour. If the pointer does four complete revolutions in one minute, this is 4/50 of a mile per minute, which is forty-eight miles per hour.
Simple Episcopes

Constructional Details of Two Easily-made Projectors

An episcope is a projector for showing images of ordinary pictures on a screen, and its operation is exactly the reverse of an ordinary camera. The device consists simply of a lens and a box, and as the light reflected from a small picture is thrown on to a much greater screen area, a strong light is needed.

Lenses

The lenses can be cheap magnifying glasses, such as may be obtained for 6d. Both episcopes here described use these lenses.

Having decided upon the maximum width of picture to be used (say 6 in.) and the corresponding screen size (about 3 ft.), a test of the lens may be made as follows. A window bar 3 ft. long is focused on a piece of paper, and (at the right distance from the window) an image 6 in. long is formed. The distance between paper and lens \(d\), Fig. 1.\] gives the correct lens position in the episcope (Fig. 2).

For the lenses used, \(d=8\) in. approximately, the episcope box is 6 in. by 10 in. It may be a converted biscuit tin, or built up. The curved part acts as reflectors for the two bulbs, which should be placed at the centres of curvature as shown. The holders are fixed in the top of the box and holes 1 in. diameter are needed. An old centre-bit will make these easily, using a block of wood on the other side of the tin to steady it for cutting.

A hole 6 in. square is made in the back of the box and covered from inside by a thin piece of glass. This is held by tin clips soldered inside. A square “door,” covered with felt, holds the picture against the glass, and the holder is hinged at the bottom, a clip holding it shut (Fig. 3).

Lens Tube

The lens tube is a cocoa tin minus the lid; a hole being made in the bottom, leaving a ledge which supports the lens. Soldered tin clips will hold it in. The hole in the tin, and the hole for the lens tube, are too large for the brace and bit, so a simple tool can be made as shown, out of two nails, and a piece of wood. One nail acts as a cutter and is sharpened with a file.

It is best to make the hole in the episcope on the small side, and then expand it by revolving a suitable piece of metal in it, until the lens tube just fits. The lip on the hole makes the tube much steadier.

In use, it will be found that the picture must be inserted upside down, but even then print is reversed and unreadable. This difficulty may be overcome by using a transparent screen, as shown in Fig. 3. Quite adequate illumination may be obtained by using two 60-watt bulbs.

(Continued on page 335)
Modern Explosives

How Nitrogen, the 'Explosive Element,' makes Modern Warfare possible

T0 a large extent, present-day warfare is carried out not only by armed forces on land, on sea and in the air, but, also, between the chemical factories of the nations. For, without the chemical factories of modern times, there could be no supplies of high-power explosives, and without the latter a nation would be as powerless in the hands of its enemies as a mouse within the paws of a cat.

When we reflect upon the fact that a century ago, the only explosive material known was ordinary gunpowder, and when we realise the enormous degree of damage which present-day explosives are able to effect, the tremendous strides which have been made in the science of explosives within the last hundred years is borne forcibly upon us.

Gunpowder

Although gunpowder, which is a mixture of sulphur, charcoal and saltpetre, was known to the Chinese in ancient times, it was, as far as we can ascertain nowadays, first used in battle by the English at Crecy in the year 1346. From that historic fight right up to the battles of Victorian days, gunpowder has been the main support of both victor and vanquished. And yet, strictly speaking, gunpowder can hardly be called a true explosive, for, when ignited in the open, it simply burns away rapidly and more or less harmlessly. When, however, it is fired in an enclosed space, it explodes with some force, although, of course, the energy of detonating gunpowder is relatively feeble compared with the tremendous amount of energy released by the detonation of any modern explosive.

It is a very curious fact that the element, nitrogen, which the chemistry books (speaking, of course, of the free nitrogen existing in the air) tell us is an inert and lazy element, is contained in all modern explosives which are of any use. In fact, we may call nitrogen the explosive element, for, without doubt, it is the nitrogen in explosives which underlies their characteristic action in almost instantaneously and uncontrollably releasing tremendous stores of destructive energy. Gunpowder contains nitrogen, this element occurring in the potassium nitrate (saltpetre) which is an essential ingredient of the powder. Actually, the active agent in gunpowder, and, indeed, in all modern explosives is the nitrogen atom in combination with two atoms of oxygen, or, as this characteristic configuration of atoms is called, the 'nitro group,' which chemists represent by the symbol—\( \text{NO}_2 \).

Mercury Fulminate

In actual essentials, all that any modern explosive consists of is a complex and convenient assemblage of millions of these nitro groups, which, normally, are fairly stable and harmless chemical entities. If, however, the atoms in these nitro groups receive a sudden, sharp disturbance, say, from the detonation of a grain or two of mercury fulminate, the component atoms of the groups are set into disruptive vibration. With such energy do they vibrate that they instantly fly apart, dragging after them the carbon and hydrogen atoms which comprise the remainder of the explosive. Thus what was originally a perfectly solid body becomes instantly converted into a heated gas, or, rather, a mixture of gases, whose combined volume is many thousands of times as great as that of the original solid. The molecular energy, that is to say, the energy of the flying molecules of the exploding substance is so great that it is practically uncontainable. The enormous volume of gas which has been suddenly generated by the exploding material pushes aside everything which resists its onwards rush and so results in the destruction which inevitably follows explosive activity.

Strangely enough, however, the more powerful an explosive may be, the more difficult it is to set into detonation or explosive disruption. T.N.T., for instance, or tri-nitrotoluene, is a yellow solid formed by the action of nitric acid on toluene, a liquid closely allied to benzene. Yet T.N.T. burns away harmlessly when melted and lighted, and you may even fire a rifle bullet through a cake of this material without exploding it. If, however, the nitro groups in T.N.T. are set into disruptive vibration by the shock received from the detonation of mercury fulminate or some similar compound, the whole mass of the T.N.T. instantly becomes converted into gas, releasing a truly gigantic amount of shattering energy. It is for this reason that T.N.T. is frequently employed as the bursting charge of heavy shells, and it is, indeed, a convenient explosive to use for this purpose because it evolves a good deal of black smoke in exploding and thereby enables the gunners or bombers to form some idea of the accuracy of their aim.
Nitrogen Chloride

Just as T.N.T., and its related modern explosives, are capable of exploding gunpowder, they are capable of detonating a heavy explosive, such as dynamite. The explosion of dynamite is the result of the combustion of a mixture of gunpowder and nitroglycerine, which is called "dynamite." At the beginning, the explosive is ignited, and the resulting product which it has expanded has been termed "dynamite." Nobel made millions out of this simple idea, for, subsequently, a combination of nitroglycerine and gun-cotton appeared on the market as "cordite," which was (and is) employed as the propellant charge of rifles and guns. It is, perhaps, a curious twist of fate which made Nobel bequeath a portion of his fortune to the establishment of a Peace Prize, and to the founding of international prizes in medicine, literature and the arts, for, having brought into being the means of destroying mankind, he seems, indeed, that we have more or less by dint of the inevitable knowledge of atomic power. Then will come the ability to produce atomic power. One day, however, some genius will hit upon the much sought for secret of atomic power. Then will come the ability to produce atomic power. One day, however, some genius will hit upon the much sought for secret of the Atomic Power.
Improving the
Gramophone
What the Modern Gramophone is Capable of Doing for the Intelligent User

THERE are still quite a number of people who regard the gramophone as a mere toy, and often these people possess an antique instrument incapable of reproducing, with fidelity, the recorded frequency obtainable to-day.

The introduction of electrical recording in 1925 created a whole set of new problems for the engineers; in those days gramophones had very short horns, quite adequate to pass the frequencies of acoustical records, but incapable of reproducing the new electrical recordings. In 1923 there was formed a body known as "The Expert Committee"; these gentlemen were all amateurs, one being an expert on soundboxes, another on horns, etc., and by exchanging ideas, and constant experiment, the hand-made acoustical gramophone of to-day was born.

Wilson Formula

A formula was devised known as the "Wilson Formula," and roughly speaking this consisted of a very long small bore tapering tone-arm leading into a tapering conduit at the end of which the horn was inserted. At first, these horns were straight, and about five feet long, but owing to considerations of space, and appearance, the result was the "Expert" horn, made by Mr. E. M. Ginn.

The "Expert" Senior Gramophone

In this respect paper mâché was found to be ideal; this material, when made up, was found to possess a number of advantages, thus, it was easily worked to the desired shape, it was immensely strong, and finally, being acoustically dead, it did not favour any particular instrument.

The soundbox was a problem in itself, and to this day I believe there is only one man who really understands the fundamental principles of soundboxes—Mr. W. S. Wild, of Clapham, was the "box" man on the Expert Committee, and it was he who pioneered the small diaphragm, the sprung stylus-bar, and believed in what he called "mass inertia." Briefly, this meant that the box should weigh anything up to sixteen ounces, the reason for this was to keep the "box" steady, and allow the stylus-bar to waggle as much as possible, aided by the springs and gasket-rubbers. He claims, and rightly, that the ordinary commercial "box" with pivoted stylus-bar is incapable of being tuned to concert pitch, as the stylus-bar not being sprung, but pivoted, could not "waggle" to the extent that the "wild" box stylus-bar does.

The illustration of E. M. O. Mark XA shows how this firm have tried to make the instrument more compact and the results on this and the Expert machine are very fine. The latter model seems to concentrate on a deeper bass with good definition, and a very commanding body of tone, the XA is particularly good for definition above all else; the bass does not seem so strong, but in my opinion the general clarity of the machine as a whole is slightly superior to the "Expert." The cost of either model is roughly £25. For best results, the use of fibre needles is advised.

Rawlplug Electric Hammer

THE RAWLPLUG CO. have just put on the market an efficient electric hammer suitable for boring holes in such hard materials as concrete, brick, stone, etc. It can also be used for hacking, pointing and chase cutting.

It is compact, and is wired for either A.C. or D.C. supply. Power consumption is approximately 170 watts. This works out at about one-sixth of a penny per hour, assuming power at 1d. per unit. Motor speed is approximately 4,500 revs. per minute.

There is no danger of the toolholder being shot out as it is locked in position in the hammer, and held clear from it until the drill is presented to the surface. A rubber shield prevents debris from entering the toolholder guide.

The hammer is driven by an electric motor having two V-section canvasshielded rubber belts giving minimum slip and wear. This flexible drive prevents undue shocks to the motor shaft.

The hammer is supplied with 9 ft. of 3-core tough rubber flexible cable, special Rawlldrills sizes 6-14. Ejector and Tommy Bar and costs £7 10s.
The Principles of the Submarine—Part 3

By R. L. Maughan, M.Sc., A.Inst.P.

The Engine Room is the Heart of a Submarine, and here are Installed the Powerful Diesel Engines and Electric Motors which propel the Craft

It has been said that the submarine owes its existence to the invention of the diesel engine and the electric storage battery. The truth of this remark lies in the fact that an electric motor driven from charged accumulators does not depend upon the consumption of oxygen for its operation, and that a diesel engine when made to drive an electric motor converts the latter into a dynamo which re-charges the batteries.

A heat engine in operation requires a large and continuous supply of oxygen, and it is evident that a vessel propelled under water by such an engine would be obliged to rise to the surface at frequent intervals in order to replenish from the atmosphere the inroads made on its cargo of air by engine and crew. On the other hand, the supply of electricity contained in storage batteries is not inexhaustible, and a boat depending solely upon an electric motor for its propulsion could comfortably remain submerged for lengthy periods, but might conceivably find itself stranded in mid-ocean by the premature consumption of its store of electricity. Since the submarine torpedo-boat has to navigate under two very different conditions—on the surface and submerged—it is supplied, therefore, with two different sets of motive powers to meet with the special requirements of these conditions. When in the submerged state it is driven by its electric motors, air being scarce and precious, and when on the surface by its diesel engines, where the supply of air is abundant.

Although these two motive powers may operate independently, they may be coupled to advantage when the boat is on the surface, for here the mechanical work produced by the diesel engine is shared between the propulsion of the boat through the water and the driving of the generator which re-charges the storage batteries.

The Engine

A diesel engine is a device for producing mechanical force by burning a fuel in an enclosed space. The enclosed space lies between the scaled end of a hollow cylinder and the crown of a piston which slides closely but smoothly within the confines of the cylinder. These remarks, however, are true of all internal combustion engines, but the special characteristic of the diesel engine which distinguishes it from other heat engines in this class is its particular method of igniting the mixture of air and fuel. The ordinary petrol engine relies upon a spark generated by an auxiliary apparatus for the ignition of the fuel air mixture; but in the diesel engine the swift compression into a small space of the air already present in the cylinder is sufficient to heat that air up to the point of spontaneous combustion, with the admixture of fuel. Physics offers a ready explanation of this fact in terms of the molecular theory of gases. According to this principle the temperature of a gas is determined by the velocities of its constituent molecules, so that the problem of raising the temperature of a gas is solved by giving its molecules greater speeds. One
method of doing this is to reduce the volume of the gas suddenly without giving its molecules any time to transfer their energy to their surroundings, obliging them, therefore, to move in a state of greater agitation, the external manifestation of which is a rise in temperature.

Dr. Diesel

In thermodynamics such a compression is described as adiabatic, and the first successful application of this principle was made by Dr. Diesel in the design of a heat engine in which the drive of a piston into a cylinder adiabatically compressed and heated the air in the cylinder to an extent which rendered it immediately combustible with the fuel present. The combustion of the fuel air mixture takes place when the piston is almost at the end of its compression stroke, crankshaft, and the oil is then blown in under the combined pressures of air delivered from the two-stage compressor and of the oil itself fed from the supply pump. The form of the valve nozzle causes the oil spray to divide into fine particles which face the air and spontaneously ignite in it, since the adiabatic compression of the air in the cylinder has already raised its temperature above the flash-point of the oil. As this piston moves down in its power stroke and approaches the bottom of the cylinder, an exhaust port C is uncovered a fraction of a second before the scavenging port D, and a blast of air which has been drawn into the crankcase through a breather valve E during the piston's upward stroke and compressed in the crankcase by the down-stroke of the piston, passes into the cylinder through the air port D and sweeps out the mixture of gases then being contained in a least volume. The process of combustion is a chemical reaction between the fuel, an organic compound, rich in carbon and hydrogen, and the oxygen of the air in the cylinder, enabling the carbon and hydrogen to satisfy their chemical affinities for oxygen by forming a host of gaseous compounds which require considerable space for their existence. The lack of immediate space between cylinder head and piston crown at the moment of their generation causes them to exert great pressure on the piston, which is thereby driven down the cylinder, and by harnessing this continued drive to a crankshaft by means of a connecting rod a source of mechanical power is made available.

These major principles have been recognised and applied in practice since their first demonstration by Diesel fifty years ago, but the existence of the diesel engine in its modern form has been made possible only through the continued perseverance in the solution of subsidiary problems concerned with the preparation and admission of fuel and combustion air, the scavenging of burnt gases, the lubrication and cooling of the engine's moving parts, and the manufacture of metals and alloys most suited to this type of heat engine.

Operating Principle

The operating principle of the diesel engine is illustrated in Fig. 8. When the piston in the working cylinder is almost at the end of its compression stroke a small quantity of fuel oil is suddenly sprayed into the air compressed between cylinder head and piston through a valve A in the cylinder head. Access to the cylinder is gained when the vertical needle in this valve is lifted for a short time by the action of a cam B on the

This is done in the two-stage compressor by taking the air to its final pressure in two distinct steps and cooling it after each step. Air is drawn through the valve H into the water-cooled spiral of the first stage cooler. The suction stroke of the upper part of the piston draws over the cooled air into the narrow part of the cylinder, where it is subject to a high internal pressure and delivered through the valve J and the second stage cooler to the head of the engine. The mixing chamber of the piston and cylinder pumps fuel oil from the storage tank and supplies it at the required pressure to the needle valve in the working cylinder head. The crankshafts of both air compressor and fuel pump are geared to the shaft of the working cylinder in order to deliver under pressure air and oil at the moment the needle valve opens to give access to the combustion cylinder.

Silent Exhaust

A desirable quality in any heat engine is a silent exhaust, and in a submarine it is especially important to make the discharge of exhaust gases as noiseless as possible when the boat is surface cruising under the motive power of its diesel engines. This is arranged (see Fig. 9) by receiving the spent gases from the exhaust port of the cylinder through a broad, water-jacketed chamber containing baffle plates spaced at intervals across its axis, and a perforated water tube mounted above the plates to pass along the length of the chamber. The curtain of water shed by this tube cools and condenses the exhaust gases and makes their impact on the outside air less forceful and consequently less noisy.

The highly specialised nature of the submarine as a sea-going craft makes it necessary to equip it with equally specialised mechanism. In principle any heat engine could be used to propel a boat on the surface of the sea, but the Diesel engine is chosen for this purpose in submarines because it satisfies the special requirements of this type of boat to a greater degree than any other kind of internal combustion engine. The main advantage of the submarine engine are safety of operation, high speed of revolution, swift reversibility, and high economic value in weight, space and fuel consumption. All of these, with the exception of weight economy, are offered by the diesel engine, and the continued endeavours of metallurgical research and engine design are being directed towards the remedy of this single defect.

Highly Suitable

The compact structure of the diesel engine makes it highly suitable for operation in the confined spaces of the submarine's engine room, where space for air and movement are not over-abundant. For a given output of horsepower, the diesel engine occupies only about a quarter of the space required by the power plant in a coal-burning ship, and not quite one half of the space needed in an oil-burning vessel, while the fuel consumed by the diesel engine is hardly more than one third of the amount needed in a marine steam engine developing the same horsepower. The diesel engine's method of burning the fuel by the heat generated by the adiabatic compression of the air in the cylinder has a greater margin of safety in an enclosed boat than the memory of boiler or electric spark, particularly as the submarine's atmosphere is always liable to contain a mixture of oxygen and hydrogen evolved from the storage batteries which could be exploded by a spark. The main defect of the diesel engine from the point of view of usage in a submarine is its heavy

![Fig. 8.—Working diagram of two-stroke port scavenging crankcase compression Diesel engine](image-url)
Soap-Making At Home

An Article of Practical Interest, Showing How Serviceable Soaps May Be Prepared from Simple Materials

Soap-making is one of the several directions in which domestic scraps may be utilised. And, more than this, soap-making, although it has in our modern times climbed up to the status of a vast and mass-scale, technically-controlled industry, is an operation which can be carried out under home conditions with the minimum outlay in "plant." All that is required for the purpose are a few old pans and dishes and some type of gas or electric stove on which the various materials may be heated up.

Although soap-making on the small scale does not necessitate the possession of any chemical knowledge, the amateur who embarks upon this interesting, useful (and, perhaps, profitable) occupation should at least have some idea of the nature of the process which he is controlling. For this reason, therefore, the following explanation of the nature of soap must be given, although, no doubt, readers who are well versed in chemical science will choose to skip over it.

Ordinary Soap

Ordinary soap consists of the sodium salt of one or more "fatty acids," these peculiar acids being so-called because they enter into the composition of all fats and most animal and vegetable oils. In most of these fats and oils, the fatty acid is combined with glycerine, the product being technically known as a "glyceride."

Now, the main constituents of fats are the glycerides of stearic and palmitic acids which glycerides are commonly known as "tristearin" and "tripalmitin" respectively. These glycerides are solid at ordinary temperatures, and they make up the bulk of most solid fats, such as lard, tallow, bone-fat, etc. There is, however, the glyceride of oleic acid (known frequently as "triolein") which is liquid at ordinary temperatures. This glyceride constitutes the basis of the majority of animal and vegetable oils, such as olive oil.

A quantity of soap made from kitchen grease. The soap is shown "in the crude," i.e. before pressing and refining.

When any of these glycerides (such as tristearin, tripalmitin or triolein) are heated up with caustic soda or caustic potash, there is formed a thick, frothy mass which contains free glycerine and the sodium or potassium salts of the various fatty acids which existed in the glycerides. These fatty acid salts constitute nothing more nor less than ordinary common soap. The sodium salts of the fatty acids are hard at ordinary temperatures and they constitute the hard soaps, whilst the potassium salts are semi-liquid and form the soft soaps.

Essentials of Soap-Making

Here, therefore, we have the essence—the "theory," if you like—of practical soap-making. In its essentials, the process of making soap consists in heating up animal or vegetable oils or fats with caustic soda or potash until all the natural glycerides contained in the oil or fat have been split up into glycerine and fatty acid, which latter will, of course, immediately combine with the caustic soda or potash present to form the resulting soap. This process, whereas the fat or oil is split up or decomposed by means of caustic soda or potash is known as "saponification" from the Latin, sapo, soap.

It must be understood that only fats or oils containing these naturally-occurring glycerides can be saponified and converted into soap. Mineral oils, such as paraffin, creosote, petroleum, etc., do not contain glycerides, and hence they cannot be turned into soap. Naturally-occurring resins, however, contain much saponifiable matter and therefore all such materials can be utilised for certain types of soap-making.

The amateur who desires to embark upon the interesting task of soap production has many raw materials from which to choose. All fat-containing kitchen scraps, grease, etc., may be utilised for the purpose. Suet, tallow, lard, butcher's fats of all descriptions, the natural oils, such as olive and castor oil, raw linseed oil, cotton-seed, rape, coconut, cod-liver, whale, palm and a host of other vegetable and animal oils may all be used for soap production, although if these oils are used alone, the tendency will be for a soft soap to be produced.

The process of soap-making does not consist in heating up an undetermined quantity of fat or oil with a similarly unetermined quantity of caustic soda or potash, for, if this method were adopted, either the soda would be present in excess, in which instance, the product would be unusable, or the soda (or potash) would not be present in sufficient amount to completely saponify the fat or oil, and, in this instance, of course, the soap product would be contaminated with unsaponified fat which would also render it unusable.

Heating the Oil

In all practical soap-making operations, therefore, it is absolutely necessary to heat up the fat or oil with exactly the requisite quantity of caustic soda or potash which is necessary to saponify it completely.

In order to avoid the necessity of bringing in abstruse chemical calculations, the reader undertaking the task of soap-making may simply refer to the table accompanying this article, from which he can read at a glance the necessary amount of caustic soda (or caustic potash) which is required for the complete saponification of most of the well-known fats and oils. Using this table the amateur soap-maker can turn out a very satisfactory and useful soap product at his very first attempt.

It should be noted that caustic soda or caustic potash are the saponifying materials employed. The beginner in soap-making,
however, is advised to use caustic soda only, for not only is caustic potash more expensive, but it also gives rise to soaps which are naturally soft and pasty. Caustic soda (sodium hydroxide) must be employed. It will not suffice to use ordinary household or naturally caustic potash, more expensive, but it also gives rise to soaps which are suitable for not only it; caustic potash more expensive, however, is advised to use caustic soda only. 

The Process

Suppose we are utilising ordinary tallow for our purpose, we shall find on reference to the Saponification Table printed in this article that sodium is exactly 14 per cent. of caustic soda to saponify it. We therefore weigh out a known quantity of tallow, place it into a glass beaker or other suitable vessel, and add to it exactly 14 per cent. of its weight of solid caustic soda dissolved in a little water in order to make up a strong solution of the soda.

The tallow and the caustic soda are now heated up in a pan of boiling water, the mixture being being graduatedly for two or three hours. During this time, the mixture is well stirred, and it will froth up and form a thick, homogeneous mass. When no further changes take place, the vessel containing the mixture should be removed from the pan of water and some common salt well stirred into it. This will precipitate a thick curd which will comprise the required soap, whilst the liquid part of the mass will now coagulate mainly of a solution of salt in glycerine.

The curd, after cooling, should be filtered off through muslin or similar cloth and then pressed into suitable shapes. If caustic potash has been used in the above process in place of caustic soda, salt should not be added at the final stage, and, on cooling, a jelly-like mass of soft soap will be produced. If, however, salt is added in this latter instance, a portion of the potassium soap will be converted into the sodium soap and thus the normally-produced soft soap will be hardened up considerably.

In the above process we have, in a nutshell, the basic working principle of soap-making. Although the soap product obtained as above may be completely suitable for many uses, such as floor scrubbing, etc., it will certainly not suffice for average toilet purposes, since it will be devoid of attractive appearance and will also be entirely inimical of any pleasant colour. Moreover, it may still carry traces of salt and glycerine which will render it unpleasant for toilet use.

Toilet Soap

There are many ways and means of converting this "soap base" into refined and toilet soaps or into soaps for special purposes. First of all, the soap may be dissolved completely in hot water and again "salted out" by means of the simple process of throwing salt into the solution. It should, however, be filtered off, pressed and dried. A much purer product may then be obtained by this simple means. The purified soap may again be dissolved in water or it may be very carefully melted, and into this dissolved or melted product may be incorporated a suitable aniline dye and a few per cent. of perfume mixture.

Not all dyes are suitable for soap colouring, since many of them fade under the influence of the slight amount of alkali which all soaps contain. The reader, however, will find suitable soap-colouring dyes tabulated in a convenient form on this page.

Now, with regard to the perfuming of the soap. The exact composition of the perfumes of many of the proprietary soaps is maintained a well-guarded secret, but the amateur may take it as a general rule that almost any pleasant-smelling essential oil will suffice for soap perfuming. In the ordinary household soaps, oils of spike, lavender, myrrh, lemongrass, saffras, pine and citronella are commonly used, but in most instances "compound" or mixed perfumes are actually employed. Here, for instance, are some actual formulae of soap perfumes of the compound type:

<table>
<thead>
<tr>
<th>Rose Perfume</th>
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<th>Oil of Geranium</th>
<th>Oil of Cinnamon</th>
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</table>
| Complicated Formulae

Many of the more complicated formulae for soap perfumes contain as many as thirty different ingredients. There would, however, be little use in burdening this straightforward article with such complexities, for every manufacturer will himself be able to make up suitable perfumes from whatever oils he may have available. In all cases, however, only a few drops of the perfume should be added to each purified "melt" of soap. Using a hard soap base, such as the one above mentioned, it is easily possible to manufacture any number of medicated and "special" soaps. By adding to the soap base small quantities of disinfectants and antiseptic substances, such as carbolic acid, coal tar, hexabrood creosote, the various disinfectant soaps may be prepared. Sulphur soap is made by adding finely powdered sulphur to the soap mix. Boracic soap is prepared by re-dissolving the purified soap in a solution of borax.

The various brands of brown transparent soap are produced by carefully drying purified soap base and then by shredding the material and by dissolving it in warm alcohol (methylated spirits will do). The spirit solution is then evaporated down, whereupon the soap is left as a brown, translucent mass.

Liquid Soaps

Liquid soaps very frequently comprise merely strong solutions of ordinary soap, suitably perfumed and dyed, and usually the lower than the cost of these liquid soaps the greater the amount of water they contain. Sometimes, however, liquid soaps contain small amounts (2-4 per cent.) of sodium silicate and/or sodium metasilicate which improve their detergent properties.

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This picture of the completed and painted locomotive gives a good idea of the realistic appearance of this remarkable model.

Building a 2½ in. Gauge Model of the “Flying Scotsman” — 3

Constructional Details of the Inner Boiler Barrel, Boiler Casing and Cab

The inner boiler barrel is a piece of 2½-in. diameter solid drawn copper tubing, and this must have the ends carefully filed square till it measures exactly 16 in. long. There are five ½-in. water tubes, and after being bent to shape, the ends are silver-soldered into holes drilled in the underside of the boiler barrel (see Figs. 17 and 25). The centre line for the holes for the front ends of the water tubes is ½ in. from the front end of the boiler barrel, the centre line for the holes at the rear end being ½ in. from that end of the boiler barrel. The centres of the holes are spaced 1 in. apart at the rear end of the boiler, but the holes are staggered at the front end, as shown in Fig. 26, which shows all the tubes soldered in place.

Boiler Ends

The boiler end castings are turned to fit the boiler barrel and are silver-soldered in place. In the front end, two holes ½ in. and ¾ in. diameter are drilled for the steam pipe and blower respectively (see Fig. 16), and these are silver-soldered in place at the same time as the boiler end.

Before fixing the rear boiler end in place it is riveted to the back plate, which is made of ⅛ in. sheet brass, and shaped as in Fig. 18. These are brazed together at the same time as the boiler end is silver soldered into the boiler. Holes are drilled through the back plate and boiler end, and tapped for the ½ in. steam regulator, blower valve, water gauge, check valve, and pressure gauge fitting (see Fig. 18). It should be noted that the steam pipe is a piece of ¾ in. diam. copper tube, and this passes right through the boiler.
through the boiler, and is bent back into the firebox, thus forming the superheater. Pieces of 1/4 in. angle brass are riveted to the sides of the back plate for fixing to the outer casing.

The safety valve bushing is silver-soldered in the top of the boiler barrel in the position indicated in Fig. 25.

Boiler Casing

This is made from a piece of 1/4 in. sheet brass measuring 191/4 in. by 101/4 in. After making saw cuts for the firebox throatplate, the metal sheet is formed into a tube 31/4 in. in diameter, lapped and riveted on the underside with 1/4 in. copper rivets. The firebox sides are shaped as shown in Fig. 17, and the throat plate is built up with 31/4 in. sheet brass and fixed to the firebox sides with 1 in. angle brass.

The smokebox front can be turned from a 31/4 in. gunmetal boiler end, with a central hole bored 21/4 in.; two small lugs are silver-soldered on to carry the hinge of the door, which is 21/4 in. diameter. This is made from a piece of 1/8 in. sheet brass, domed with a hammer. The hinges are made of 1/8 in. strip brass with lugs silver-soldered on, and are riveted to the door. A piece of 1/8 in. German silver wire is used for the hinge pin. Fig. 27 shows the smokebox front and hinged door in position.

The chimney, which is turned from a casting, is bored 1 in. and riveted to the boiler casing. The casing can now be set up on the chassis to the correct height, with the smokebox saddle in position (Fig. 28) and marked out for the handrail knobs. Holes are drilled 1/8 in. for the screwed stems of the knobs, which are fitted with brass nuts on the inside of the casing on each side of the 1 in. diameter hole which is drilled for the safety valve.

Fixing the Inner Boiler Barrel

The rear end of the inner barrel is held in the casing by 3/16 in. screws each side on to the brass angle of the back plate. The front end of the inner boiler barrel is supported by a 3/16 in. screw at a distance of 21/2 in. from the front of the outer casing. This screw is clearly shown in Fig. 25. The boiler casing is held in position on the saddle by a 1/8 in. screw on each side, the firebox sides resting on the footplate, to be eventually attached by the cab.

The Cab

The spectacle plate for the cab (see Figs. 18 and 29), is cut out of 1/8 in. sheet brass with 1/8 in. angle brass riveted and soldered to the sides. The cab sides are also cut out of 1/8 in. sheet brass, and the windows are beaded round with 1/8 in. half-round brass (see Fig. 4). The cab roof is bent to shape, and on top is soldered a piece of 1/8 in. flat brass, curved to suit. Standard round-head buffers are screwed into the front buffer beam, and a steel coupling hook with German silver links is fitted.

Wheel Splasheers and Nameplate

The wheel splasher are castings, which are cleaned up and soldered to the footplate. The nameplate, which is soldered on, above the central splasher on each side of the engine, is cut out of 1/8 in. brass, and the name can either be engraved, or painted on. The steam pipe covers between the footplating and smokebox are made of 1/8 in. sheet brass bent to shape (Fig. 15).

The axle-driven pump is fitted with a bypass, the hollow chamber for which is made out of 1/4 in. square brass drilled up and tapped, and fitted with a No. 0 (male end) union cock. When this is in the horizontal position it is bypassing (Fig. 21). The vacuum pipe is made up of 1/4 in. tubing, and the lamp bracket is a standard 1/8 in. scale fitting.

The cylinders are lagged with thin Russian iron, held in place by 1/8 in. round-headed screws.

(To be continued)
In these days of mental stress and nights of black-out, many of us are looking around to find some way of occupying our evenings on a subject far from the topic of the war. Of course, there are numerous hobbies and pastimes to which we can turn attention for respite, both scientific and otherwise, assuming that we are not already enthusiastic followers of some particular line. However, in this short article I intend to discuss some of my experiences in the realm of photomicrography, as the results have been well worth the small amount of trouble expended upon them.

How to obtain Successful Results with the Simplest of Apparatus

By D. Leatherdale

Definitely a beginner, since I spoilt my first plate by exposing the backing instead of the emulsion, through sheer ignorance! Yet I think my second photograph was not far from excellent, purely by chance.

Arranging the Microscope

The microscope is set up vertically, with the substage condenser in position. A filter should be employed, and normally a "daylight blue" glass will suffice, but if the object to be photographed is highly stained, a filter of the opposite colour will give sharper definition. Thus a section stained red would require a green filter.

The beginner is well advised to use the lower powers of his microscope, as the exposures are easier to estimate, the focusing is simpler, and the pictures are clearer, all of which are important points to the novice. The majority of my photographs shown in the accompanying illustrations were taken using a 2/3 in. objective and a x10 eyepiece. A 100 watts pearl lamp was used, built in a well-ventilated cocoa-tin housing, and great care must be taken to see that the mirror of the microscope centralises the light correctly, or else the pictures will be unevenly illuminated.

In some microscopes annoying reflections may occur from the inside of the tube of the instrument, in which case it should be lined with velvet or matt-surfaced black paper.

Supporting the Camera

The type of camera used may depend on the work in hand, but I used a very cheap box camera. As a camera in the normal sense it functioned extremely crudely, so no harm was done when I cut the back completely off. A piece of finely ground glass 2½ in. by 3½ in. fitted into the hole at the back as a focusing screen. That was all the preparation needed to adapt it for photomicrography. I supported it on end above the microscope eyepiece by the simple expedient of putting a pile of books on either side of the microscope, and laying a couple of rulers across the top. This held the camera in position quite satisfactorily.

The choice of a plate or film is an important matter, and one that can only be decided after several trials have been made. Ilford Process Film meets all requirements, and is supplied ready cut in 2½ in. by 3 in. pieces. Process Plates are also obtainable, but I think film is easier to store, develop and manipulate generally. If it shows signs of bending when placed in the back of the camera it may be straightened by laying the focusing screen upon it. But the most useful point about this type of film, and plate, is that it has a very

From the few failures I have had valuable lessons have been learned, as I do not consider a spoilt negative a wasted one. It is important to find out why a thing goes wrong before trying a second time. The apparatus described is simple in the extreme, and, apart from the microscope itself, costs very little. It is an advantage to be already in possession of a microscope, as such an instrument is admittedly expensive, and at least an elementary knowledge of its use is essential before attempting photomicrography. When I began taking photographs through my microscope I was

(Left) The proboscis of a blowfly. (Right) A human tongue papillae

(Left) The proboscis of a blowfly. (Right) A human tongue papillae

(Left) Stinging hairs of a nettle. (Right) Hydra fusca

(Left) A n elder tentacle. (Right) A snail's palate

(Left) Stinging hairs of a nettle. (Right) Hydra fusca

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From the few failures I have had valuable lessons have been learned, as I do not consider a spoilt negative a wasted one. It is important to find out why a thing goes wrong before trying a second time.
Then placed centrally over the eyepiece, exposures are thus allowed a greater margin of error.

Making an Exposure

We are now ready to start trying some photomicrography. The room must be darkened, except for a red working lamp and the microscope illuminant, and the object displayed to its best advantage in the field of the microscope, bearing in mind the previous remarks about making use of the low powers. The condenser is racked up to give the brightest light, and if it has a diaphragm this should be closed sufficiently to gain a clearer definition of the finer details of the object. And remember to choose a suitable filter now. The camera is then placed centrally over the eyepiece, resting on the two rulers, and the shutter left open. The ground glass screen is rested on the film guides, and any minute corrections in focusing made.

Books Worth Reading

"Modern Ignition Simply Explained." By Harold H. U. Cross. Published by The Technical Press, Ltd. 144 pages. Price 5s. 6d. net.

The purpose of this handbook is to describe, in simple language, the fundamental principles of the electrical ignition systems used upon motor vehicles, aircraft, motor-boats, tractors, tanks, etc., and without delving too deeply into technical details, the differences between the various systems of ignition now in use are clearly explained. The book is divided into twelve chapters, the subject matter dealt with including Ignition Systems in a Nutshell; Modern Magneto and Coil Sets; The Art of Timing, and Care and Maintenance. It is interesting to note that among the various magneto described in the book, the old model T Ford Magneto finds a place. The book is well illustrated in half tone and line, and there is also a full index.

"Soldering, Brazing, and the Joining of Metals." By Thomas Bolas, F.C.S.

Published by Percival Marshall & Co., Ltd. 84 pages. Price Is. 6d. net.

This is an enlarged edition of a useful handbook which deals with all kinds of soldering; including soft soldering; electric wire and cable jointing; "wiped" joints; brazing; burning; and soldering with tinfoil. The book is well illustrated in line and half-tone.

THE STRAND MAGAZINE

When M. Curie and his brother announced in 1898 that they had discovered a curious thing about crystals of quartz they did not imagine that their observation would make television possible, or protect us from icebergs and submarines. Readers of this paper are likely to be interested in an extremely able article in the April issue of "The Strand Magazine" on "Discovery of Inaudible Sound." The amazing uses of supersonic waves are described, and it is rightly pointed out that although nobody knows yet the limits of their usefulness, they are already one of the most important safeguards to our country. This same issue of the "Strand" also contains a particularly interesting account of the training of the Naval diver. It is obtainable through all Newsagents and Bookstalls.

POSTAL MILLIONS

The Commercial Accounts of the Post Office for the year ended March 31st, 1939, just issued, shows some interesting figures. There is a surplus of £10,254,578, a reduction of £973,302 on the surplus for the previous year. This reduction is largely accounted for by the increase in staff costs.

During the year 8,150,000,000 letters, and 184,332,000 parcels were dealt with. This is an increase of nearly 4 per cent. in the case of letters and 3 per cent. in the case of parcels.

There were 2,122,400,000 local telephone calls and 111,553,000 inland trunk calls. Out of 5,715 telephone exchanges, 2,025 are automatic. There are 46,518 call offices and 3,235,498 telephones. Wire used in connection with the postal services runs to 15,299,000 miles. The Post Office employs a staff of 283,371 and owns 17,384 motor vehicles. Business transacted with the public reached the enormous figure of £21,602,217,000. Capital expenditure during the year amounted to £21,385,156. It was mainly for the development of the telephone system.

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Chemistry for Beginners

Strange enough, the various compounds of boron are usually left severely alone by the average experimenting amateur, who frequently labours under the misapprehension of regarding boron as a "difficult" element to experiment with. True it is that boron is not altogether easy to isolate in its pure state, yet the element is one which gives rise to numbers of most interesting compounds, the majority of which may be simply, and inexpensively, prepared.

Boron is the element of borax, that well-known sodium salt of boric (or boracic) acid, which has been known and used for at least a couple of thousand years. The ancient Arabs called borax "buraq," whilst the Romans, during their civilisation, gave it the name by which it is now known. Hence, when the chemical element contained in borax was first isolated in 1808 by J. L. Gay-Lussac, and J. Thénard, nothing was simpler than to call it "boron," the borax element.

Boric Acid

Borax and boric acid are two very closely related compounds, borax being the sodium salt of boric acid. What is usually termed "boric acid" is chemically spoken of as ortho-boric acid, and it possesses formula H3BO3. There are, however, two related boric acids, one, meta-boric acid, BO(OH)3 (or H3BO3), and pyro-boric acid (sometimes called tetra-boric acid), H4B6O11. Ordinary borax is the sodium salt of this pyro-boric acid or tetraboric acid, and is thus chemically spoken of as sodium pyroborate, or sodium tetraborate. It has the chemical formula Na2B4O7.10H2O.

Both boric acid and borax are well-known commodities which have an extensive usage. Boric acid is known and used for its mild antiseptic properties, whilst very large amounts of borax are employed in the production of vitreous enamels and, also, of optical glass. Borax forms an ingredient of soldering fluxes. It is also sometimes employed as a food preservative, whilst its other uses are concerned with soap manufacture, varnish production, laundry work, and in certain types of metal production.

No. 13.—The Chemistry of Boron. Simple and Interesting Experiments with Borax, Boric Acid and Related Compounds

Most of the borax of the present day comes from the vast deposits of calcium borate which are to be found in Bolivia. Boric acid, on the other hand, comes from Italy, in which country it occurs (particularly in Tuscany) in the volcanic jets of steam which are common in that region. These steam jets condense to small ponds of water which become highly charged with boric acid. Thus the water is simply drained away and evaporated to crystallising point.

It was only at the beginning of the 18th century that boric acid became known. It was then made from borax and was called in England Sul solutivum. Towards the end of the same century, its acid nature became recognised and it was then termed "boracic acid." It is only within comparatively recent times, however, that "boracic acid" has been abbreviated to "boric acid." Both "borax" and "boracic acid" are one and the same substance, but "boric acid" is nowadays the correct, and the scientific name to use for this material. Both "boric acid" (which, as we have already seen, is chemically termed "ortho-boric acid") and borax are inexpensive and plentiful materials, and, using them as a starting point, we can prepare a considerable number of different substances from them.

Meta-Boric Acid

Take boric acid (ortho-boric acid), for instance. If we heat a quantity of this material in an open basin on a water-bath it becomes converted into meta-boric acid, H4B6O11, with loss of water. Thus:

{\[
2\text{H}_3\text{BO}_3 \rightarrow \text{H}_4\text{B}_6\text{O}_{11} + 2\text{H}_2\text{O}
\]}

This fusion by heating meta-boric acid to a temperature of 140°C. for some time it becomes converted into pyro-boric (or tetra-boric) acid, H4B6O11. This pyro-boric acid may, also, be obtained directly from ortho-boric acid ("ordinary" boric acid) by heating it to a temperature of 140°C. All the three boric acids are white, crystalline solids which are only slightly soluble in water. Ordinary boric acid (ortho-boric acid), in particular, is more soluble in alcohol than it is in water. Consequently, when a spirit lamp is fed by methylated spirit containing boric acid in solution, the flame is always tinged with the very characteristic livid green hue of boron compounds.

Boron Trioxide

We now turn to a very interesting compound, to wit, Boron trioxide, B2O3, which is readily made by heating boric acid to redness. At this temperature, the acid fuses and gives up the elements of water:

{\[
2\text{BO(OH)}_3 \rightarrow \text{B}_2\text{O}_3 + 3\text{H}_2\text{O}
\]}

This fusion is best carried out in a procelain crucible, although, for convenience, it may be conducted in almost any vessel. The fused mass of boron trioxide cools on cooling to a glass-like solid which very slowly absorbs moisture from the air and becomes opaque.
Boron trioxide is interesting in respect of the fact that it is capable of dissolving many metallic oxides, and becoming coloured by them. Borax itself has also this property—upon which the well-known laboratory "borax bead" tests depend. In these tests, a small amount of borax is fused on the end of a glass rod, or platinum wire, and then touched with or dipped into a quantity of the oxide or other compound whose metallic nature it is required to determine. The "bead" is again re-fused, whereupon it will acquire a colour due to the solution of the metallic oxide in the borax, this colour being characteristic of many metals. Thus, a borax bead will give rise to a blue colouration of the bead, iron compounds will colour the bead yellow, nickel compounds will impart to the bead a brownish hue, manganese compounds will produce an amethyst tint and so on. Full particulars of these "borax bead" tests are usually to be found in any elementary textbook of practical inorganic or analytical chemistry, such as can be referred to in any Reference Library.

Sulphur Trioxide

Using boron trioxide, we have a convenient method of preparing sulphur trioxide, which latter compound, when dissolved in water, produces sulphuric acid. To make sulphur trioxide (not dioxide) boron trioxide is fused with potassium sulphate. White clouds of sulphur trioxide are expelled. In order to collect these, the heated crucible should be dropped into an enclosed vessel provided with an outlet tube dipping below water at its extreme end. By this means, a reasonably strong stream of the gas may be obtained.

Another very interesting compound which can be obtained from boron trioxide is boron trifluoride. It is, in fact, one of the few fluorine compounds which the ordinary amateur can prepare. To make boron trifluoride, BF₃, we mix equal quantities of powdered fluor spar and powdered boron trioxide, and heat the mixture with concentrated sulphuric acid. The ensuing reaction is a complicated one, but boron trifluoride will be evolved as a colourless, pungent gas which will give rise to dense white fumes in contact with moist air.

Boron trifluoride is truly remarkable in respect of its violent affinity for water. So great is this affinity that if a piece of paper be held in a stream of the gas, the paper will actually become charred owing to the abstraction of water from it by the gaseous boron trifluoride.

Boron trifluoride is not an inflammable gas. It is, however, very soluble in water, one volume of water dissolving nearly 1,000 volumes of the gas at 0°C. By passing boron trifluoride gas into water until the latter liquid is saturated, a syrupy fluid will be obtained. This is often called fluoboric acid although its composition is by no means certain. However, the liquid is a strongly corrosive one, and it will char paper, wood and similar materials. Hence it should be treated with due respect.

If this "fluoboric acid" is diluted to half its volume with water, it will form meta-boric acid (which will separate out in white crystals) and hydrofluoroboric acid, HF₃, which will remain in solution. Hydrofluoroboric acid will usually dissolve metallic hydroxides with the formation of borofluorides (or fluoroborates). Some interesting salts may therefore be made by taking advantage of this property.

**Boron Trichloride**

Boron trichloride, BCl₃, is another reaction for when it is mixed with ammonia (in equal volumes) it gives rise to the compound, BF₃NH₃, which is also a white, crystalline material.

Metallic boron, B₂, may interest some experimenters, although it is not a pleasant substance, being lachrymatory or tear-producing in its effects. It is a yellow solid which is made by passing a stream of carbon bisulphide vapour over boron trioxide which has been mixed to a paste with soot and lubricating oil, the mixture being heated to bright redness.

This experiment must be performed with much care and preferably out of doors, since carbon bisulphide has not only an overpowering and disgusting odour, but its vapour is extremely inflammable when mixed with air. Using common-sense precautions, however, the experiment is quite safe.

And now as regards the element boron itself. It is not very easily prepared, and, indeed, to prepare it in a state of 100 per cent purity is an extremely difficult operation.

**Preparing Boron**

The experimenter, however, can best prepare boron by heating in a covered crucible sodium and boron trioxide. The mixture should be fused at the highest possible temperature and the greatest care must be taken to see that no water comes in contact with the crucible, otherwise the heated sodium will explode. After the mass has been fused for five or ten minutes, allow it to cool completely, and then immerse the crucible in dilute hydrochloric acid. After any action has died down, the acid (with the crucible still immersed in it) should be boiled. As a result, a dark brown powder will be observed. This, which is fairly pure boron, should then be filtered off, washed and dried.

Boron, although it can exist in other forms, appears, when prepared by this method, as a greenish-brown powder which is insoluble in water or most acids. When acted upon by cold concentrated nitric acid, however, it is converted into boric acid. With concentrated sulphuric acid, too, a similar result occurs.

(Continued on page 335)
April, 1943
NEWNES PRACTICAL MECHANICS

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THE Wellington I, although it has not been very long in service with the R.A.F., is already familiar to the general public because of its marked success in the Wilhelmshaven raid early in the war, which has received a great deal of publicity in the film The Lion Has Wings. Apart from its aerodynamic qualities the Wellington is of exceptional interest to the engineer because it represents the successful incorporation of the Vickers-Wallis geodetic construction in an aeroplane of very modern performance.

Geodetic Construction

Geodetic construction is a method of building shell structures with a lattice-work of pre-formed metal sections. The term "geodetic" is derived from a surveying word used in the measurement of distance on the earth's surface, and means "termine". The geodetic member is the shortest distance between two points in a curved plane surface, lying on that surface. By making the fuselage, main planes and tail unit from curved panels consisting of intersecting diagonal members (each with a slight curvature) it is possible to divide each panel into a very large number of small areas braced by diagonals joined at their mid points. It is well known that slender struts are much stronger in tension than in compression, and it has been found that it is possible, by linking these curved diagonals in the middle, to convert the compressive force developed in one into a tension load in the other. As soon as the member in compression begins to bow minutely, the other diagonal takes the load in tension and the deformation is arrested. Such struts formed by the length of geodetic member between links is very short (about 9 in. on the average), so that the panels made by them are small, and when fabric covered they are capable of resisting air pressures of 1,000 lb./sq. ft.

Since geodetic construction forms the shell, albeit an openwork one, of a structure, and carries all the essential loads—were it not for the need of detachable panels for maintenance work and the like, it would be unnecessary to have spars and frames—it is more truly a stressed-skin than the wings of that name, which have to be given spars and ribs to help carry their loads and conserve their shape.

First Geodetic Aeroplanes

The first geodetic aeroplanes, which were flown in 1935, were the Vickers 44/31 biplane and a monoplane, the former built to an Air Ministry Specification for a general-purpose aeroplane, and the latter as a private venture to beat the specification for Great Britain. The experiences gained in service with the Wellesley were incorporated in the Wellington, a twin-engined bomber to the Air Ministry Specification B9/32, and resulted in there being a considerable difference between the prototype, which appeared in 1936, and the production machines which began to reach the squadrons in 1938.

The Wellington is a mid-wing monoplane with very high-aspect ratio tapered wings. With normal construction it is more economical to make low-aspect ratio wings, i.e. the ratio of span to chord is small, because the weight increases greatly with the span. The geodetic structure, on the other hand, does not get proportionately heavier as the span increases, in fact it is only on the high-aspect ratio wing that its qualities come into their own. The great advantage of having a large-span, narrow-chord wing is that the take-off is much better and all climbing characteristics, including the ceiling, are improved without a corresponding increase in drag.

Wings

An idea of the principle of the geodetic wing has already been given. In practice, the ideal has to be modified slightly in the interests of production and maintenance. The leading edge is metal covered and is made in detachable sections; the trailing-edge portions (over the flaps) and the ailerons are too small, together with being comparatively lightly loaded, to make them worth constructing on any but the conventional duralumin tube with fabric covering construction. The main portion of the wing has three very light tubular spars and three light transverse members which act solely as locations for the geodetic panels. The main portion of the wing is almost free from obstruction so that the
A SIDE, PLAN AND FRONT VIEW OF THE VICKERS-ARMSTRONGS WELLINGTON I.

NOTE: ALTERNATIVE HEAVIER ARMAMENT TO THAT SHOWN IS ALSO IN USE.

SCALE OF FEET

0 10 20
Winds driven Cycle

WIND as a driving force is not utilised as was the case in the past, although neither the windmill nor the windjammer is extinct. However, there is a possibility of wind being used as a driving force being used in connection with the bicycle. An application to the British Patent Office has been made to protect an invention which has for its object the employment of wind power to aid the propelling of cycles. It comprises an air motor, a rotor with vanes mounted on the crank axle and rotatable within a casing supported from the frame of the cycle. There is a funnel extending aft of which the bomb-aimer’s position is located, the first pilot is seated on the port side with the reserve on a movable seat on his right. Behind the pilot’s come the wireless operator and the navigator’s post, with their equipment, including a hatch with a transparent dome for making astral and solar observations. This section, which is over the main planes, contains tanks and the general amnesties for the crew, including an embarrasing centrally situated and lofty necessity! Beneath the floor lie the bomb storage, and the bomb bay. The last member of the crew is seated in the rear turret—a journey of some ten or twelve yards along a narrow catwalk. It is a peaceful spot this—on manoeuvres in peace time—remote from the throng of the engines, with a magnificently detached view in all directions, including the latticed perspective of the interior and one’s own wing tips and tail plane, at the same time comfortably warmed by a controllable jet of air from the exhaust heater, with only the occasional movement of the elevator spar or rudder control rods to disturb the calm.

Tail Unit

The fixed surfaces of the tail unit are made with geodetic panels like the wing, while the upper surface is not. The tail spar, ribbed, fabric-covered type with mass balances and servo tabs. The tips of all surfaces (including the main planes) are formed of detachable metal-skinned panels easily replaced in the event of damage.

The engines on the Wellington I are the Bristol Pegasus XVIII nine-cylinder air-cooled radials of 885 h.p. They are fitted with two-stage superchargers which give two operating altitudes of 4,750 ft. and 14,750 ft.—this makes the machines speed much more equal at all heights. These engines are carried on curiously humped nacelles designed to improve the flow of air over the main plane, and are covered with N.A.C.A. type cowlings with cooling outlet gills. Bristol nose exhaust-collector rings, together with a sharded crankcase cowling unique on British aeroplanes, are also fitted. De Havilland controllable pitch airscrews are used. The Wellington has also been fitted with the 1,075 h.p. 12-cylinder vee liquid-cooled Rolls-Royce Merlin and the 1,375 h.p. 14-cylinder sleeve-valve Bristol Hercules air-cooled engines, which must increase the already high performance considerably.

Superior to German Plane

The comparable German aeroplane with the Wellington is the Heinkel He 111k Mark V which, with two 1,200 h.p. liquid-cooled engines, weighs 24,900 lbs., has a range of 2,170 miles and a maximum speed of 274 m.p.h. The 111 Mk. V is a more modern development of a design contempororary with that of the Wellington. The structure of the Wellington should be far less vulnerable than the Heinkel and its defensive fire power is far superior to that of the three manually-operated German machine guns.

The British dark green and brown "shadow-shading" is now familiar and needs no describing. The undersurfaces of large bomber aircraft are painted dull black, as are the airscrews and engines. Red, white and blue cockades are carried on the sides of the fuselage and under the wings. The cockades on the top surface of the wing are dark red and blue only. It will be understood that to give too particular colour-scheme details in wartime would be undesirable.
Holland's Water Defences

By G. LONG, F.R.G.S.

All the peaceful neutral nations next to Germany have found it necessary to construct defensive lines, but Holland alone boasts a Maginot Line of mud. At first sight, mud and water may seem a poor defence, but a moat may be as good as a wall, and twice in her history Holland has fought a great power, and won, helped by mud, so that she still holds her independence, and rules the third greatest colonial empire in the world.

Nearly half of Holland is far below sea level, so trench digging is out of the question, and when such defences are constructed, they must be built up with mounds of earth carted to the spot in lorries.

The Dutch main water-line runs from Muiden on the Zuider Zee past the Lower Rhine to the River Waal, a distance-allowing for bends-of perhaps 80 miles. There is a further water-line to the south of this to fill up the gap between the Waal and the Belgian frontier. There is also another water-line between the main defences and Germany. This is called the Grebbe Line, which runs from the Zuider Zee, near Amersfoort Junction, to the Lower-Rhine at Wageningen, a distance in a straight line of about twenty miles, but double this by numerous windings.

Enough to Stop Tanks

It is proposed to flood these water-lines to a depth of about twenty-eight inches. It has been suggested that this may be enough to stop tanks and mechanical transport, but would prove no obstacle to cavalry. It should be remembered, however, that when the water has stood on the land for some time, the heavy clay beneath becomes soggy beyond belief, and may even bog horses. Further, these polders—as the low-lying meadows are styled—are anything from 12 to 18 ft. below the level of the sea, and of the canals which intersect the country in all directions. It follows, therefore, that the Dutch could easily let in enough water to drown the invaders while they were floundering in the swamp. It is certain, however, that they will use as little water as possible, because every gallon which flows on the polders will remain there until it is pumped out again, and extensive flooding would mean huge damage and enormous expense to rectify afterwards.

The unique nature of the soil in Holland is well illustrated by the famous case of the "floating farm." During drainage works in 1848, near the village of Aalsmeer, some acres of meadow were separated from the Zuider Zee by a windmill, and were driven by a violent wind to the other side of an inland lake. The farmer appealed to the authorities for help, as his fields were now on the wrong side of a large pond, and were detached from the rest of his farm. Incredible as it may seem, these fugitive fields were towed back and pinned down by piles and poles so that they remained in their original position. We have shown, then, that the soggy soil and flooded belts of the Dutch water-line should offer serious resistance to an invader. We must next describe how these remarkable defences were constructed.

A Strange Paradox

Here we come to a strange paradox. The water-line was not made to let the water in; it was constructed to keep the water out. The Dutch water defences were built for a fight against the water, and it was a battle with many defeats.

In 1277 thirty-three villages were overwhelmed and 20,000 acres of land were inundated. In 1421 thirty-five villages and 25,000 acres were overwhelmed, but the greatest disaster of all began on All Saints Day, 1170, when two great rivers overflowed, and in the course of 200 years the floods continually extended until a million acres had been submerged and the Zuider Zee was formed. To-day this is being drained, and in a few years hence fertile fields will take the place of this vast shallow sea. It is interesting to remark how they were built.
that land reclamation was not possible until the engineer had provided mechanical means for pumping out the water. Tradition avers that the first hydraulic windmill was set up near Alkmaar even to-day is celebrated for its huge number of drainage windmills. I have counted 17 close together on the road between Alkmaar and Hoorn. In 1643 an engineer named Leeghwater proposed draining 17,000 acres of the Haarlemmer Meer by means of 100 windmills. Long before the work could be performed, the Meer had increased to more than 45,000 acres and was growing month by month and threatening to overwhelm the countryside.

Steam Power

The tremendous task of draining this inland sea was successfully performed about a century ago, but by means of steam power.

Eight hundred million tons of water had to be pumped out merely to empty the lake, with at least another 100 million tons from infiltration and rainfall, and all below the lowest point of outlet.

A canal was dug encircling the lake and the excavated soil was used to build a stout bank of earth on the inner side. The canal was 40 miles in length and as wide as the Thames at Hampton Court. The area of enclosed water was 70 square miles. English engineers constructed three engines each capable of pumping a million tons of water in 25 hours. In four years this vast lake had been pumped dry, and two years later it was producing splendid crops.

The total cost of the work was about £200,000, but 41,675 acres of splendid land were reclaimed, and form the richest fruit and flower gardens in all Holland. I have seen splendid crops of strawberries and vivid beds of tulips flourishing where once deep waters flowed. The average selling price of this land was £80 per acre, but some of it sold as high as £940 per acre.

Picturesque Windmills

These polders require draining all the year round, because all surplus rainfall has to be pumped out.

There are hundreds of picturesque windmills, some of them still at work, but since the great electrification scheme for Western Holland a couple of decades ago, most of the drainage is done by electricity. The electric plant lacks the picturesque effect of the windmills, with their neat thatched towers and wide, sweeping sails, but it is immeasurably more efficient.

Windmill pumps can only work when there is a wind, but the electric plant works only when it is required, and then stops.

Switches are controlled by floats, and when the water-level is correct the current is switched off.

We have fully described the water defences against rivers and inland lakes, but there are others against the sea itself. Along the broken coasts of Gröningen and Friesland, and on the fringes of Zeeland, there is a system of impolderisation from the sea.

The shallow sea area to be drained is encircled by dykes, the water is pumped out, and soon contented kine are grazing where once the ocean rolled. Some of the sea dykes are enormous, faced with granite, and held together by osier branches woven throughout the mass. The biggest dyke is at Heider—5 miles long—and there are many more. Seen from the polders, they resemble huge railway embankments streaming through the fields.

A Dyke Threatened

When a dyke is threatened by a storm it is protected by osier branches placed upon its face, and its height is raised by planks filled in with clay. Flood-time is by law a state of emergency, and the engineers have autocratic powers to commandeer anything necessary, whether men or materials, to prevent the water breaking through. Even houses have been demolished to supply stop-gap materials, but the old story of the heroic tiny child who saved his country by stopping a leak with his chubby hand is not believed in Holland. All the Dutchmen

PREVENTING GLASS FROM SPLINTERING

There seems to be a widespread belief that strips of brown paper gummed to windows in criss-cross patterns will prevent, or minimise, the shattering of the glass by bomb explosions.

The research laboratory of the "Triplex" Safety Glass Co., Ltd., has carried out a number of experiments to ascertain the shatter point of different types of glass now frequently seen in use as intended to prevent splintering, and the following results may be of general interest.

Ten types of glass were tested. The method of test was to take a number of samples of each type 12 in. square and to drop on each one a steel ball weighing 1 lb., from a minimum height, increasing the height by stages until the sample broke into two or more large fragments. Mere cracking was not recorded as a break. The shatter point given below is the average taken of the various samples.
A "Spare-Parts" A.C. Three Valve Receiver

As the Name Implies, this Mains Receiver is Built from a Varied Assortment of Old Parts

This month we give details of a three-valve A.C. mains receiver which has recently been constructed from a varied assortment of old parts, some of which were over five years old.

Despite the very rapid advances that have been made in radio design since the majority of the components and the circuit design were current practice, excellent results have been obtained.

Circuit Considerations

The circuit is given in Fig. 1, which shows that a screen-grid H.F. stage is used in conjunction with a leaky grid detector, and a pentode output valve. Power supply is derived from an H.T. 8 Westinghouse metal rectifier.

A single tuned circuit precedes the screen-grid valve, the volume control not only increasing the resistance in the cathode circuit when volume is required to be reduced, but also reducing the resistance shunted across the aerial tuning coil, thus by-passing the aerial input voltages. This method of both cutting down the aerial input, and at the same time reducing the gain of the valve, gives a continuously variable control which is very effective in practice.

Choke capacity coupling is used between the detector and output stages, a tuned-grid coil being used. This arrangement gives a good compromise between selectivity, sensitivity and quality.

It will be noted that a 500-ohm resistance is inserted in the reaction circuit, which otherwise is quite normal. This is to stop parasitic oscillation caused by the detector valve going into oscillation at a frequency determined by the combined constants of the reaction circuit, and that portion of the grid circuit between grid and earth, and shown up by the set going into oscillation, especially on long waves, with the usual slight "plop," but without giving the usual heterodyne whistle on the received signal, and before the full reaction amplification has been reached.

From the point of view of progressive and efficient reaction, we have found the following combination of values to give the best results:

Detector anode by-pass, 0.0002 mfd.; Reaction condenser, 500 ohms; Detector grid condenser 0.0001 mfd.; Detector grid leak, 0.25 megohm.

We cannot guarantee that these values are the best for every coil, but they will certainly suit the majority. Coupling between the detector and output stages is by means of a parallel-fed transformer, the transformer ratio being 4:1.

It will be noted that the screen of the output valve has been decoupled. This is not always necessary, but the valve we used had a fairly high magnification and was getting beyond its best. Decoupling of the screen was necessary to stop L.F. oscillation.

<table>
<thead>
<tr>
<th>LIST 0/ COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 screen-grid H.F. valve, Marconi VM84B.</td>
</tr>
<tr>
<td>1 triode detector valve, Marconi MND4.</td>
</tr>
<tr>
<td>1 pentode output valve, Marconi MPT4.</td>
</tr>
<tr>
<td>1 H.T. 8 Westinghouse Metal Rectifier.</td>
</tr>
<tr>
<td>1 mains transformer to suit H.T. 8 rectifier, with 6-volt 4-amp. L.T. winding.</td>
</tr>
<tr>
<td>1 two-amp 0.0005 mfd. tuning condenser.</td>
</tr>
<tr>
<td>1 aerial tuning coil, Colvern B.10.</td>
</tr>
<tr>
<td>1 tuned grid coil with reaction, Colvern G.3.</td>
</tr>
<tr>
<td>3 valve holders.</td>
</tr>
<tr>
<td>1 L.F. transformer, R.I. Parateed.</td>
</tr>
<tr>
<td>1 10,000 ohm volume control.</td>
</tr>
<tr>
<td>25,000 ohm resistance.</td>
</tr>
<tr>
<td>5,000 ohm resistance.</td>
</tr>
<tr>
<td>250 ohm resistance.</td>
</tr>
<tr>
<td>500 ohm resistance.</td>
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<tr>
<td>0.25 megohm resistance.</td>
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<tr>
<td>10,000 ohm resistance.</td>
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<tr>
<td>5,000 ohm resistance.</td>
</tr>
<tr>
<td>1,000 ohm resistance.</td>
</tr>
<tr>
<td>2 mfd electrolytic condensers (or 5 x 0.4 block).</td>
</tr>
<tr>
<td>2 mfd. 200 volt working paper condensers.</td>
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<td>0.0001 mfd. condensers.</td>
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<td>0.0005 mfd. condensers.</td>
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<td>0.0005 mfd. condenser.</td>
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<td>0.01 mfd. condensers.</td>
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<tr>
<td>0.01 mfd. condensers.</td>
</tr>
<tr>
<td>1 mfd. condenser.</td>
</tr>
<tr>
<td>50 mfd electrolytic condenser.</td>
</tr>
<tr>
<td>0.01 mfd. condenser.</td>
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<td>0.01 mfd. condenser.</td>
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<td>0.01 mfd. condenser.</td>
</tr>
<tr>
<td>10 mfd. condenser.</td>
</tr>
<tr>
<td>0.25 megohm.</td>
</tr>
<tr>
<td>2 H.F. chokes.</td>
</tr>
<tr>
<td>2 on-off switches, if not included in coil unit.</td>
</tr>
<tr>
<td>0.0003 mfd. reaction condenser.</td>
</tr>
<tr>
<td>1 L.F. choke capable of carrying 50 mA.</td>
</tr>
</tbody>
</table>

Fig. 1. The circuit diagram.
Alternative Components

The only alternatives that are likely to cause any bother in constructing a receiver to this design are coils and valves.

We have dealt with the coils above. As regards valves, any high-impedance triode will do for the detector, but it may be necessary to alter the value of the 50,000 ohm load resistance shown in our diagram. With the pentode output valve, different makes require different values of bias resistance, and screen decoupling may not be necessary. The only really serious difficulty lies with the H.F. valve.

Some readers may not have a spare variable-mu valve, in which case volume control may be placed in the L.F. stage, or simply as an aerial shunt across the coil. In either case, the cathode resistance of the H.F. valve must be joined direct to earth. Note too that different types of H.F. valve may necessitate alterations to the values of the two resistances forming the screen-grid potentiometer. These details may be obtained from your valve catalogues, but the values we have chosen are right for most valves.

A different type of power supply may of course be used, provided that it delivers sufficient voltage at the current of 50 mA. A valve rectifier will be found quite suitable.

Construction

Either baseboard or chassis construction may be used. The former is cheaper and easier, but the latter makes a more workman-like job and certainly helps to avoid instability. If a wooden baseboard is used, it is essential to cover it with metal foil.

Whichever method you use, mount the components first, and then do the wiring—the whole job can easily be done in three hours. We used a metal chassis which we had by us and the layout is shown in Fig. 2.

Provided the H.F. and detector valves are not metalised, it is advisable to put a valve screen round both or to erect a metal screen between them.

Wiring is very simple, and easily checked when completed, but be sure to check it before you insert the valves and switch on. If you are at all doubtful, insert a 60mA fuse in the H.T. positive supply lead.

Results to be Expected

Results will naturally depend on the efficiency of the valves and coils. Provided these are not much below normal, it will be possible to get quite good quality from the local stations, and also to receive a good many of the continental stations free of interference. Should selectivity prove to be insufficient when receiving a foreign programme or a very powerful local station, reduce the volume control and bring up the reaction nearly to the point of oscillation. The selectivity will then be at maximum, but quality will suffer somewhat.

The 0.01 mfd. condenser between the pentode output valve anode, and earth provides fixed tone control, but may be altered to a variable tone control in the normal way, viz., by the inclusion of a variable 20,000 ohm resistance between the condenser and earth.

H.T. supply is obtained from an H.T. 8 Westinghouse metal rectifier, and is smoothed by an L.F. choke and a 8 mfd. condenser.

The total current taken by the three valves will be approximately 50 mA, and the unsmoothed output of the rectifier about 380 volts, which is not sufficient to allow of the use of a mains energised loudspeaker. For those who have mains energised speakers with field resistance of 2,000 ohms, and who would like to use them, we would point out that the voltage drop in the field will be about 125 volts, so that, allowing for a smoothed output of 250 volts, the rectifier must deliver 375 volts, unsmoothed, at 50 mA. In this case, it will be advisable to use the H.T. 9 rectifier.

Components

The complete list of components is given on the previous page. We have given the makes we have used ourselves, but good results will be obtained from alternatives provided they are of reliable make. If alternatives are used for the coils and transformer, for example, the connections will be numbered or lettered differently, and we call your attention to an article which appeared in the June 18th, 1938 issue of our companion journal Practical and Amateur Wireless, where details of the connections to a good many of the earlier types of coils which are likely to be used in a receiver of this type, are given.

Plan and Underneath Wiring Diagram of the “Spare-Parts” Three-Valver

[Diagram of a circuit with labels and components]
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Geography Without Tears

A PATENT has been granted in the United States for a microscopic
traveling map. This consists of a tiny globe and includes a magnifying glass and means for illumination. On one, wonder whether the intention of the inventor was to produce something that could be used as a point of reference for planning journeys? For many years there has been a movement to encourage students to learn geography, particularly those living in areas where it is not easily accessible. The map is intended to be held up to a lamp or sunlight, allowing the viewer to see the details of the globe clearly. It is a useful tool for anyone who needs help with navigation, whether they are traveling long distances or just exploring their local area.

“A Dummy” Addicts

AUTHORITIES on the management of infancy, including that adept in the art of training other people's children—the mature maiden aunt—condemn the artificial test known as a “dummy” or “soother.” For one reason, the creation involved may materially increase the sale of dummies. As the opinion was more difficult to cure than what I will term the “dummy” addict. But the latter has formed a habit which cannot be broken without the use of a cascade of tears. Sometimes the child improvises a “dummy” in the shape of its own finger. With the object of preventing such a habit, a patent has been granted in America for an infant's hand guard. This anti-finger sucking device is a stiff shield which loosely encloses the hand of a child and is secured to the youngster's wrist. In order to combine amusement with protection against a bad practice, there is a nattle affixed to the guard.

Indoors Clothes Line

A LL FRESCO drying of clothes is subject to that fickle jude, the weather. As a consequence, especially during the winter, there is visible in the kitchen a wooden horse—no relation to its Trojan namesake—expiated with dump underwear. The household is intriguised by a newly devised clothes line for indoors drying. To fit this up, all that is necessary is to attach a small suction cup to one wall, draw a line of a spool, and fix two other cups to any convenient wall. An adjustable fixture permits the line to be stretched across any room, at any height, and at any angle, and to any length not exceeding 25 feet. It should be added that the suction cups do not damage the walls. This oblige contrivance will enable one fair to festoon their kitchen with laundered likeness. It will also be very accommodating in the matter of airing garments.

A Good Point

PENCIL sharpening by hand is an art. Like other arts, it is dependent very largely upon natural aptitude. And, of course, imagination! A keen knife in the hand of a man quarrels with his tools, a keen knife is an important factor in producing an effective, tapering point. For many years manufacturers have striven to improve on the sharp point of the lead, but the point is apt to become too delicate for use. A patent has been granted to a man who has invented a method of making a sharp point that will not harm the lead. This is accomplished by cutting a fine groove into the lead, which is then sharpened to a point. The result is a pencil that will write smoothly and will not break the lead. Such a pencil is particularly useful for fine writing and drawing.
MINIATURE MAGIC
Effective Tricks that can be Performed with Articles carried in the Pockets

By Norman Hunter
(The Well-known Conjurer of "Maskelyne's Mysteries")

Further Articles on the Secrets of Conjuring will appear Regularly and Exclusively in this Journal

Fig. 1 and 7.—(Left) A neatly made fake nut, dividing across the centre, enables the conjurer to remove the nut from a string held by spectators. A duplicate unprepared nut is exchanged for it and given for inspection. (Right) Cutting a matchbox in two with a card. The metal attachment makes it possible to open and close the box although the card passes through it.

YOU take a box of matches and, with a playing card or visiting card, proceed to saw through the box. When the box is apparently cut in two with the card projecting on all sides, you open and close the drawer of the box exactly as if there was no card in the way.

Fig. 1 shows the secret of this ingenious trick. The matchbox is prepared by marking. This is glued to the underside of the cut matchbox, and a stout wire operates through these slots, the ends being fixed to the small blocks of wood so that the drawer can be apparently pushed in and out. Fig. 3 shows the exact working of the trick. When the card is removed, the fake matchbox is secretly changed for an ordinary one, which can then be left about for inspection.

A Matchbox Trick

Another neat matchbox trick consists of changing the entire contents of a box of matches into a silk handkerchief or other article. For this purpose a row of matches is glued on to the bottom of the drawer, on the outside. The handkerchief is tucked into the drawer, which is then put into the case. If the drawer is opened upside down, the false row of matches gives it the appearance of being full. If one loose match is included, this may be struck to light a cigarette, and so give weight to the suggestion that the box is empty. It is now only necessary to close the box, turn it over and open it, when the handkerchief comes into view. (See Fig. 4.)

Wrapping a match in a handkerchief, breaking the match, and then showing it restored is a handy trick that can be done in two different ways. One is to have a match concealed in the hem of the handkerchief. When the visible match is wrapped up it is this hidden match which is broken, leaving the original one whole. You then offer to repeat the trick with a borrowed handkerchief. This time you do not break the match at all, but hold it up to someone's ear and, by clicking your thumb nails together, imitate the sound of a match breaking. As you have just done the trick...
MATCHES GLUED TO BOTTOM OF DRAWER

HANDKERCHIEF INSIDE DRAWER

Fig. 4.—By closing the box and turning it over, the handkerchief taken into view and quite obviously broken a match, the breaking will be accepted as genuine. All you then have to do is to shake out the whole match and return the borrowed handkerchief.

Mysterious Card

Fig. 5 shows a card that turns to a box of matches. The card is hinged with a strip of paper or linen tape to fold on to the top of the box and a label, steamed from another matchbox, is pasted on the half of the back of the card not attached to the box. Show the card by holding it with the hidden box in the palm of your hand, your fingers gripping the card at the edges, and holding it facing squarely to the audience. Pass the other hand downwards in front of the card and, in doing so, fold the card down on to the box. The box may, of course, be filled with matches, and some of them can be struck to prove the box genuine.

From matches to cigarettes is a short step. The cigarette shown in Fig. 6, when dropped into the little metal tube also the cap is removed, only the match can be extracted, as the hollow cigarette is closely wedged in the tube and its presence cannot be detected. To remove the cigarette after the performance, the key shown in the illustration is employed. The straight end of this is threaded to screw into a hole in the closed end of the fake cigarette. When this has been done the fake can be removed from the tube by pulling the key.

Cigarette and Handkerchief

Pushing a lighted cigarette through a borrowed handkerchief without causing any damage is a trick that will always cause excitement. The necessary apparatus consists of a metal false thumb tip painted flesh colour. Wearing this on your right thumb, where it is invisible as long as the hand is kept moving, the borrowed handkerchief is taken and spread over the closed left fist. The right thumb now poker down the centre of the handkerchief, and in doing so leaves the thumb tip hidden in the handkerchief. The cigarette, which, by now should have been smoked down to a fairly short length, is placed deliberately, burning end down, into the handkerchief. Of course, with a pair of minute spring plug points which fit into holes in the opposite half of the nut. The joint is so accurately made that it cannot be distinguished when the halves of the nut are pressed together. In performing the trick the plain nut is given for inspection with the string. The nut is then changed in the hand for the fake nut, and the latter is threaded on the string. This nut, can, of course, be removed by simply pulling it apart, after which the pieces are concealed in the folds of the handkerchief and the plain nut again given for inspection.

Coloured Discs

A somewhat similar trick, but with a totally different secret, consists in removing one of three coloured paper discs from a string without damaging discs or string. To do this you have duplicates of the three coloured paper discs handy, and as soon as the colour is announced you palm the corresponding duplicate, tear the correctly coloured disc off the string under cover of a handkerchief, and hand out the duplicate, concealing the pieces as before.

Vanishing a halfpenny by covering it with a metal cap and a brass ring is an old trick which, for the sake of completeness, is explained in Fig. 8. The ring is covered with white paper and the trick is worked on a sheet of similar paper. The metal cap is placed on the ring, and both are lifted and put over the halfpenny. The cap alone is lifted and the halfpenny seems to have vanished, because it is hidden by the paper with which the ring is covered.

Improved Version

This trick is so well known as to be hardly worth doing, but there is an improved version which will catch the knowing ones. In this the brass cap, as shown in Fig. 9, is hollowed out just sufficiently to fit tightly over a halfpenny. One side of the halfpenny and the edge are turned down to present a plain, smooth, bright surface. The trick is worked on a sheet of white paper with an unprepared ring, exactly as if it were the old version. When cap and ring are put over the halfpenny, the cap is pressed down and the halfpenny literally becomes part of it. The cap is then lifted, showing that the coin has gone. Someone who knows the old method either picks up the ring or asks to see it, suspecting the
presence of the paper masking. You then calmly pick up the ring and show that it is unpacked.

Another neat trick consists of putting a penny on the table with three small cardboard pill-box lids. A member of the audience is asked to put the penny under any of the three lids while the performer's back is turned, yet he is instantly able to indicate the correct cap. The secret is that the penny has a short length of human hair firmly stuck to its edge so that it projects about half an inch. The fine hair is quite invisible to anyone who is not actually looking for it, but the performer can find it quite easily, as it sticks out from under the cap which covers the coin.

Pile of Pennies

Turning a pile of pennies into a small die under cover of a metal cap is accomplished by means of a specially prepared pile of pennies. All except the top coin of the pile have the centres drilled out, leaving a rim of about an eighth of an inch all round. The pile of rims, with a whole coin on top, is fastened together with a rivet through the edges. The pile can thus be manipulated and squared up just like a pile of genuine loose coins. The little die is concealed inside the hollow stack. The metal cap is fitted over the complete pile, and when it is lifted, the sides are pinched, thus lifting the stack of coins as well. While the attention of the spectators is directed to the die thus revealed, the hollow pile of coins is allowed to drop out of the cover into the hand, and the cover can be tossed for examination while the hollow pile is secretly disposed of in a convenient pocket.

Using the Apparatus

To use the apparatus, the article to be vanished is placed in the cup, going, of course, into the lining. Holding the cup in the right hand, the performer turns and reaches with his left hand for a handkerchief with which to cover the cup. Under the screening provided by this movement he presses the top edge of the cup against his left sleeve and makes a downward stroking movement with it. This causes the sharp hook on the container to catch in the sleeve and the lining is withdrawn, leaving the cup empty. The lining remains quite securely attached to his sleeve, ready to be secretly taken off and disposed of as may be required. The cup is particularly valuable for causing the disappearance of a number of small articles, such as a bunch of matches or two or three halfpennies.

A miniature bottle that will not lie down for anybody but the performer is made to do its stuff by having the bottom weighted just right, and it is a dome-shaped piece that causes the bottle to swing to an upright position whenever it is laid down. The performer has concealed in his hand a short piece of metal rod which he introducts into the neck of the bottle when he picks it up. This rod acts as a counter to the weighted bottom, and the bottle may then be laid on its side.

Divining the order of four numbered or coloured cubes placed in a row in a box, the lid of the box is the key to an effective pocket trick. The secret in this case is a sliding panel in the lid as shown in Fig. 11. Holding the box to his forehead and pretending to read the order of the blocks by magnetic waves, the conjurer slides back the panel with his thumb and notes the order as the box passes his eyes.

One of the pencils is unprepared. The other has the centre section of the lead removed and a drop of mercury inserted. There is no apparent difference in the pencils — apart, of course, from their colour — and nobody who does not know the secret could tell which was inside the box. The performer, however, shakes the box gently to and fro endwise. The tiny drop of mercury strikes against the sides of the lead in the pencil and is sufficient to be felt with the fingers holding the box, and so the conjurer knows which pencil is inside. If no movement is felt, he knows that the unprepared pencil is there.

"The British Journal of Electrical Engineers", April, 1940.

The "B.J. Almanac" is one of the standard reference works for both the professional and the serious amateur photographer, and this year's edition is every bit as good as its predecessors in spite of the difficulties under which all publishers are working as a result of the war. The course of his leading article in the present edition, the editor, Arthur J. Dalladay, A.Inst.P., reviews the position of the photographer in the light of present conditions, and gives his readers much valuable advice. He points out that for the photographer the war has brought many problems, many surprises and many changes, some of which may be none the less important for that they are gradual and unnoticed. There will be material changes, he adds, changes of thought, habit of mind and changes in our form of life which may even revolutionise whole industries.

Among the editorial contents of this issue the articles on the photography of wild flowers, portrait landscape photography and retouching will probably have the greatest appeal for the amateur, while the professional is catered for in the exhaustive discussions on reversal processing, Hydroquinone developers, and the Bromoil process. The miscellaneous information section contains a great deal of valuable information for the beginner, and the index in the book is in simple language, while the numerous photographic illustrations and line drawings greatly assist the reader. The various chapters deal with subjects as aero-dynamics, Distribution of Weight, Gearboxes, Directional Control, Wing Fixing, Building Gears, Radio Control, Airscrews, General Design, Fuselages, Wings, Finishing, and Notes on Flying. At the end of the book are included five sheets of wiring drawings for full-scale models of well-known British aircraft.

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**THE AUTHOR**

The author is Mr. F. Horner, who needs no introduction to those in the Engineering Trade. He has been assisted by eight recognised experts and the work has been edited by Mr. A. Regnault, B.Sc. (England), A.R.C.Sc., M.I.E.E., who is the Senior Lecturer at Faraday House Engineering College.

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April, 1940

NEWNES PRACTICAL MECHANICS 323
"MOTILUS" PEEPS INTO THE

Models from Cigarette Tins

In one of the accompanying illustrations is seen the work of an amateur model maker, who has not only spent many happy hours making railway stock, but has at least one beautiful old-time ship to his credit. He is Mr. T. A. Spence of Potters Bar, and the Tank Engine and Wagon illustrated were both built from cigarette tins. They are "OO" gauge. The bodywork of the engine was constructed exclusively from these cigarette tins, cut up, with the exception of the boiler mountings and buffers. He even used the hinges of the tin to form the rails round the top of the tender. The tin itself, says Mr. Spence, is of light gauge and ideal for soldering, and in building the model I used ordinary scissors to cut out the various parts, files, pliers, electric soldering iron, and, of course, suitable metal drills. It may interest readers to know that Mr. Spence did not have the use of a vice, which obviously would have been a big help. In building the buffer bars and footplates, double thickness tin was used to give extra strength, and in lapping over the edges, these were started off with a broad pair of pliers and then hammered over. The coupling hooks were also made of double thickness tin, timned, hammered and sweated together. The raised smokebox was formed by adding two thicknesses of tin to the boiler casing, and to get the curve of the boiler barrel, Mr. Spence tied the tin round a brush handle and then soldered the seams of the boiler together.

The painting was done in flat oil paint, the maker lettering and numbering the model himself, which is taken from an O-4-4 suburban tank loco operating on the L.M.S. railway.

"OO" Gauge Bridges

Owners of "OO" gauge twin trains seem to get an enormous amount of extra fun out of this miniature railway by running on high and low levels, and recently you will remember a notice that Messrs. Bassett-Lowke, Ltd., brought out a series of gradients of simple design and construction, which were illustrated on these pages. Since then several owners have designed and built quite elaborate high level roads, and a London customer's effort in this direction is here illustrated. It will be seen from the photograph that the selection comprises a straight viaduct with double bridge over road, skew bridge and lattice girder bridges, and also two curved viaducts, and another type of lattice bridge. The models are all made of hard wood with imitation stone piers and capping, and the rest filled in with scale model brick work. I was very taken with these attractive designs, which would meet the standard dimensions of many twin train owners' outfits.

Model Loco. Sets

The cry to-day is "Models for the blackout," and in view of the added interest in model work, two splendid engineering sets have been placed on the market recently. The first is a set of finished parts for building a gauge "O" steam locomotive, viz., an L.M.S. 2-6-0 Mogul. So popular has this become that a fully illustrated sixpenny booklet has been issued on how to make the model, containing even a set of the tools needed to construct it, and already I have seen people who have built up these sets of...
MODEL WORLD

parts—people who have never built a model locomotive before. One young enthusiast in Manchester claims to have made the set up in thirty-five hours, which is only five hours longer than what is looked upon as a record.

The other set is for more advanced model engineers, and is now running in these pages—in other words the magnificent 2½-inch gauge 1-inch scale L.N.E.R. Flying Scotsman. For making this model, small engineering tools are required, and, if the turning

Far from hindering our favourite hobby, MOTILUS has been pleasantly surprised to see how the black-out has become a blessing in disguise to many enthusiasts.

work is to be done, a small lathe also, but the result is a model worthy of exhibition in any model exhibition in the country. A special list of the parts necessary, with drawing details is available, so if you are interested in either of these model sets, write to the Editor.

A Trim Model Yacht

The time for model yachting is not very far off now, so here is a picture of a model made last year by Mr. J. K. Robinson, of Dunton, Bassett, near Rugby. It has a 4 ft. long hull, hollow, and built from a solid block of African whitewood, and has balsa fabric sails. The beam is 10 in. and the depth 4½ in., with an 8-inch deep keel, 10 pounds in weight. The mast is 5 ft. in height. The yacht has a polished deck with planks marked in, and is dark brown in colour, with deck of natural wood colour. The sails and fittings have been made detachable, and the little cabin has a hinged roof. The owner has unfortunately had few opportunities to sail it, but he seems so pleased with the result that he would write to the editor, marking it "Motilus Feature," for the owner would be willing to accept any reasonable offer. I have seen the model out on one occasion, and it gave quite a brilliant performance.

High Class Model Locos.

I have recently had photographs sent me from Mr. Hugo Hurlimann, of Switzerland, of some fine examples of Swiss modelling. The top illustration is the work of one of the members of the Zurich club, Mr. Robert Hager, and represents no less than nineteen year's work. It is an exact scale model of a 4-6-0 Swiss Express Federal Railway steam locomotive, and is complete in every minute detail. The scale is 1:15, the gauge about 3½ in., and it is steam driven and coal fired, being built to operate on compressed air.

The illustration of the cab of this locomotive gives us some idea of the tremendous patience and skill behind the building of this pièce de résistance. The second locomotive, the work of Mr. Fr. Neuenschwander, of Burgdorf (of the Bern Model Railway Club), represents a 2-8-2 Bulgarian Express locomotive, and this is also a beautiful piece of work. Displayed at the Swiss National Exhibition last year (the model was built at the Swiss Locomotive Works at Winterthur), this locomotive became nicknamed the "Tobacco Locomotive. It was built by the Swiss in exchange for Bulgarian tobacco! The scale of the model is 1:20th, the gauge about 2⅝ in., and it is steam driven.

Recently turning through some of my photographs, which are many and varied, I came across the rather striking picture shown on the previous page. It is a model of

The cab of the 4-6-0 model Swiss Express Federal Railway steam locomotive.

Some fine models of viaducts and bridges.

(Motilus Feature

The Parisian, who makes a hobby of collecting models of ships in which he is interested. He is attracted by ships of all ages and types, and must have in his possession one of the most comprehensive collections in the world.

Side by side with providing lighting material for our land, sea and air forces we must place the drive for export trade to enable us to amass foreign credits for buying food and other necessities from abroad. The model-making and toy industry is alive to this, and is receiving special encouragement from Government departments. One of the most important details in this economy drive is the preparation of samples to suit the overseas market, and at a well-known works at Northampton, expert sample makers are busy making up samples of locomotives, cinemas, steam engines and other goods for export trade, which will afterwards go into production in large quantities for the overseas market.
Making An A.R.P. Pump

Construction Details of a Small Force Pump Utilising a Garden Syringe for the Pump Barrel and Plunger

The simple force pump shown in the accompanying illustrations is intended for use in pumping out water from flooded air-raid shelters, and for assisting in extinguishing small incendiary bombs. It would also prove useful in pumping water out of a butt, for garden purposes. The chief materials required are an ordinary garden syringe, two tap washers (with brass stems), two \( \frac{3}{4} \) in. brass angle fittings, and four brass discs \( \frac{3}{8} \) in. thick.

The inlet and outlet valve chambers are made in a complete unit, which can be screwed on to the end of the pump barrel, as shown in Fig. 1, the top end of the inlet chamber being soldered into a hole bored out in the threaded rose end. The discs are bored centrally, as at A, to take the ends of the angle fittings; the nozzle, which can be of slightly smaller diameter than the inlet fitting, will not foul the pump barrel when screwed in place.

Reference to Fig. 1 will make this point clear. It is also important to note that the valve chambers are soldered in place. The top end of the valve guide is closed by a brass disc, soldered on, but the top end of the inlet valve chamber must be left open, as shown. Around this guide tube a stout helical spring should be pressed, of sufficient length to act as a cushion to prevent the valve guide from burring over the outlet nozzle. The disc B, which forms the top of the inlet chamber, has a number of inlet holes drilled, as shown, and a central hole in which is soldered a short length of brass tubing, which forms a guide for the stem of the inlet valve. The disc C has a central hole in which is soldered the guide tube for the outlet valve.

Soldered Joints

When soldering these discs in place, it is important that sufficient clearance is left between the bottom ends of the short guide tubes, and the tops of the valves, to allow the valves to lift a distance of \( \frac{3}{4} \) in. Reference to Fig. 1 will make this point clear. It is also important to note that the valve chambers are soldered in place. The top end of the outlet valve guide is closed by a brass disc, soldered on, but the top end of the inlet valve chamber must be left open, as shown. Around this guide tube a stout helical spring should be pressed, of sufficient length to act as a cushion to prevent the outlet valve from burring over the outlet nozzle. A plan of the completed valve chambers is given in Fig. 2.

In Fig. 3, the inlet valve is shown in the opposite direction to that of the outlet nozzle. This nozzle can, of course, be arranged in any direction to suit requirements.

Stirrup Irons

In Fig. 4, which shows the completed pump, a simple form of stirrup is depicted, consisting of two iron rods, screwed at the lower ends to a piece of hardwood, wide enough to take an ordinary shoe, the upper ends being bolted to a metal clamping band. Soft iron rod, \( \frac{3}{4} \) in. diameter, can be used for the stirrup iron, which should be about 12 in. long. The ends of the rods can be made red hot in the fire, and flattened on an anvil (an old domestic iron fixed between blocks of wood will answer the purpose). After rounding the ends with a file, the holes can be drilled for the bolts and screws.

A stirrup, to prevent small stones, etc., from entering the valve chambers, can be made with a piece of perforated zinc, rolled to form a cylinder, discs of the same metal being soldered into the ends. A hose-pipe connecting piece can be soldered into one end of the stirrup.

Fig. 1.—Sectional view of valve chambers, and lower end of pump barrel, showing the valves in position

Fig. 2.—Plan of valve chambers with pump barrel removed

Fig. 3.—The top and bottom valve chamber discs

Fig. 4.—The completed pump and strainer, and a detail of the foot stirrup

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Masters of Mechanics

No. 55.—HENRY MAUDSLAY

A Glimpse at the Life of the “Father of the Modern Lathe”

The story of Henry Maudslay and his many-sided creative activities begins with the life of his father, old William Maudslay, a native of Bolton, Lancashire, and a working joiner by trade. Old “Bill” Maudslay made a name for himself in and around Bolton as a reliable builder of the wooden frames for the early cotton machinery, but, somehow or other, like many another super-efficient workman, he found things becoming too ‘hot’ for him in his native town. Thus it was that he threw up his occupation in Bolton and forthwith enlisted in the Royal Artillery, in which famed regiment he saw active service in the West Indies. He was severely wounded, and was subsequently sent home forthwith. By the time he returned to Bolton, he had joined the Royal Artillery and was subsequently sent home again.

Being a skilled workman, William Maudslay applied for and obtained a position in the Woolwich Arsenal, and it was during his employment at this famous munition-making centre that his son, Henry, was born on the 22nd of August, 1771, in a house which stood along the street that was later to become the Woolwich Arsenal gates.

A “Powder Monkey”

The boy Henry seems to have been given a rough time of it during his earliest years. He had little or no education, and when he was barely twelve years of age he was made to enter into the Arsenal’s service as a “powder monkey”—a wretched and unhealthy occupation which was usually assigned to young boys, and which consisted in the hand-filling of cartridges with gunpowder.

Young Henry Maudslay found himself condemned to this irksome occupation for a couple of years or more. Then, by a lucky chance, he graduated to a lowly position in the Arsenal carpenters’ shop in which his father worked. The work here was better than the monotonous and unhealthy drudgery which was the lot of the average “powder monkey”. Yet, for all his increase in status, young Maudslay did not by any means excel himself in the woodworking trade of his father. Rather, he found his main interest in the surreptitious visits which he frequently paid to the blacksmiths’ shops in the Arsenal, and in the making of many little articles of metalwork which the friendly smiths allowed him to create at their forges.

It was not more than a year or so after his father abandoned his occupation at the Arsenal that young Maudslay, at his earliest requests, was removed to work as a “lad” in the Arsenal’s smithies. Here, he plunged into his fresh occupation with gusto and delight. Within a few months, although as yet merely a raw youth, he became an expert smith, displaying his skill more particularly in the forging of light ironwork.

Trivet-Forging

Forging trivets was Maudslay’s favourite, albeit sparetine, occupation at this period; a “trivet” being, of course, a light and ornamental piece of ironwork which, resting on the bars of a kitchen fireplace, afforded a convenient stand for a heated kettle or for a plate of freshly-made toast. Maudslay’s trivet-forging had to be carried out in an uninterrupted manner, and between his many other arduous duties, but the lad at this period of his life seems to have been blessed with an understanding overseer, who recognised his inborn mechanical abilities and who, during hours of duty, was accustomed to signal his approach to the Arsenal forging shops by the loud and, indeed, the almost semi-explosive blowing of his nose, this being a tacitly assumed notification for all unauthorised jobs to be hurriedly put away in the shops during the presence of this official!

Maudslay’s original screw-cutting lathe

Maudslay got on well under the kind superintendence of his overseer. Indeed, the reputation for excellence of workmanship which he made for himself in the Arsenal metal-working shops laked even beyond the guarded gates of that official establishment. Joseph Bramah, the inventor of the hydraulic press, of a patent of the self-tightening collar of the Bramah hydraulic press. This collar consisted of a simple and effective means whereby the piston or ram of the hydraulic press was effectively sealed, thereby preventing water from escaping past it. Bramah himself had wrestled with his fundamental difficulty of “sealing” his piston for a very long time, and, at periods, he was in despair of ever finding a satisfactory solution to the problem, for without an efficient seal to the hydraulic ram or piston, the device, although perfect in theory, would have been useless in practice.

The difficulty, however, was solved by Henry Maudslay, who had at that time become the manager of Bramah’s works. Yet, despite this enormous aid which Maudslay had thus been to him, Bramah would never agree to pay the former a wage of more than thirty shillings per week. This pittance Maudslay put up with for as long as he could, but increasing family responsibilities eventually compelled him to sever his connection with the Bramah concern and to strike out on an independent existence.

Meeting with Bramah

Thus it was that Maudslay was sent for, and ushered into the presence of the great Bramah who was many years his senior. Indeed, Maudslay in this time was only eighteen years of age. Nevertheless, his mechanical knowledge, and the suggestions which he made to Bramah concerning the latter’s lock-making difficulties, so impressed the older inventor with a sense of his abilities that Maudslay found himself almost implored to take up a job in the Bramah workshops for the express purpose of carrying out the making of the new Bramah locks.

Bramah’s career has already been made the subject of an article of this series (Masters of Mechanics, No. 33). In all probability, the fact that young Henry Maudslay agreed to give up his career at the Woolwich Arsenal, and to take up work under Bramah resulted in at least a proportion of the fame which Bramah gathered to himself. There is no doubting the fact that, although Joseph Bramah actually invented his mechanical locks, much of the credit for making them must go to Henry Maudslay. For Maudslay, once installed in the Bramah workshops, devised special tools and machinery for the production of the locks, which tools enabled the locks to be turned out in large quantities, and by mechanical methods which Bramah himself had, at first, hardly conceived to be possible.

Furthermore, Maudslay’s assistance to Bramah became of vital importance in the invention by Maudslay of the self-tightening collar of the Bramah hydraulic press. This collar consisted of a simple and effective means whereby the piston or ram of the hydraulic press was effectively sealed, thereby preventing water from escaping past it. Bramah himself had wrestled with his fundamental difficulty of “sealing” his piston for a very long time, and, at periods, he was in despair of ever finding a satisfactory solution to the problem, for without an efficient seal to the hydraulic ram or piston, the device, although perfect in theory, would have been useless in practice.

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First Start in Independent Business

In this latter critical phase of his career, Maudslay had, at first, only the assistance of his wife—at one time Bramah’s pretty housemaid—and a single workman. He made his first start in independent business in a small alley off Oxford Street, London. His first customer was an artist and, at periods, he was in despair of ever finding a satisfactory solution to the problem, for without an efficient seal to the hydraulic ram or piston, the device, although perfect in theory, would have been useless in practice.

The difficulty, however, was solved by Henry Maudslay, who had at that time become the manager of Bramah’s works. Yet, despite this enormous aid which Maudslay had thus been to him, Bramah would never agree to pay the former a wage of more than thirty shillings per week. This pittance Maudslay put up with for as long as he could, but increasing family responsibilities eventually compelled him to sever his connection with the Bramah concern and to strike out on an independent existence.
sion, satisfactorily executed, brought others in its train. Gradually, Maudslay's iron-working business grew. Old customers of Bessemering him their business and, after a few years, "methodical Maudslay," as he was sometimes facetiously yet truthfully dubbed, became known for his excellence of mechanical workmanship throughout the length and breadth of London.

As in his earlydiminutive workshop, off Oxford Street, London, that Maudslay created the invention with which his name will ever be associated in the record of engineering history. This invention was that of the Slide Rest of the lathe. Based on this invention, the mechanical and power-driven lathe has developed through the ages and until it has become in modern days a device which can be put to almost any complicated precision engineering work, short of hammering and riveting.

The Slide Rest

The lathe is an old invention which finds its origin, perhaps, in the potter's wheel. In operating a pre-Maudslay lathe, the woodworker or mechanic applied and guided his cutting tool to the work in haphazard one. Scarcely two such articles produced a lathe-worked article was a very haphazard one. Scarcely two such articles could be turned out alike even by the most expert and experienced lathe operator, whilst for the quick production of a number of identical lathe-worked articles, the method was hopelessly inadequate.

Fundamentally, all the Maudslay "slide-rest" consisted of was, as its name implies, merely a metal rest for the cutting tool, by means of which the latter could be slid along the lathe in a direction exactly parallel to the axis of the work in the lathe. The slide rest held the cutting tool firmly and securely, and, by means of it, the tool was able to be applied to the work in the lathe at any required angle, and with constant pressure. Thus it was that, for the first time in history, two articles could be turned on the lathe to identical dimensions and shapes. Precision engineering, and that is nowadays called "repetition work" became not only possible, but practicable.

Standing as it may seem, Maudslay's invention and utilisation of his "slide rest" brought quite a good deal of ridicule upon his methods. The "rest" was for a long time dubbed "Maudslay's go-cart," and, thus characterised, it came in for a good deal of derision in the mechanical circles of the Metropolis at the beginning of the nineteenth century. But Maudslay was a determined man. He realised the firmness of the grounds upon which he had based his invention. By means of the slide rest, the heaviest and the most delicate turning work could be accomplished with equal satisfaction.

Machine Tools

And so it was that, in the end, Maudslay, too, in his workshop, this slide rest conformed to the "block," and who approached Maudslay in the matter of manufacturing it in large amounts. A ship's "block," it may be explained, was an article which was employed in the raising and lowering of the sails of sea-going vessels, and, as such, it was a highly important device. Brunel's block had many decisive advantages over these of the older type. It was difficult, however, to manufacture. And, indeed, there inlay blocks, the design of which he brought to Henry Maudslay to solve.

The problem involved the designing—or, perhaps, to be more accurate, the actual invention—by Maudslay of a new system of machinery for the purpose of turning out Maudslay, too, at this period, built several steamboat engines of simplicity and robustness, one of which was fitted into the Regent, a steamer which plied on the Thames for many years between London and Margate.

Screw-cutting machines, a machine for automatically drilling boiler plates, a mechanical saw, stationary steam engines of various types, coin-minting machinery, boring and mortising machines constituted only some of the many articles which Henry, Maudslay turned out from his now extensive Lambeth works. Every machine of Maudsley's was characterised by excellence of design, construction and performance. Indeed, it used to be said that just as a trained artist could point to a picture and confidently remark: "This is a Turner," or "That is by Constable," so, in like manner, it was possible for a well-informed engineer to lay his hand on a piece of machinery, or on an engine, and to state categorically: "This is a Maudslay."

Famous Apprentices

"I cannot afford to turn out second-rate work," Henry Maudslay was often wont to exclaim. In the minutest details of his creations, Maudslay—"methodical Maudslay"—was characteristically thorough and painstaking. Through his workshops proceeded many an industrious young apprentice who, having imbibed the spirit and the mechanical wisdom of the Master, went out into the greater World to make a career and to meet Fame for himself. Two suchapprentices were Joseph Whitworth and Joseph Clement. Another was James Nasmyth, the inventor of the steam hammer, and of other mechanical and power devices.

Of the personality of Maudslay, there is little to say. Honest, persevering, painstaking and industrious, entirely without "side," unspoiled by the fame which came to him, simple in nature, and ever available to his workmen and to outsiders, Henry Maudslay led, so far as the world at large was concerned, a particularly uneventful life.

Maudslay, with his full, round face, and his typical good humour, characterised the very essence of straightforwardness and industry. This pioneer died at Woolwich on 14th April, 1840, and he was buried in the parish churchyard there, where, over his grave, a cast-iron monument, made to his own design, was subsequently erected.
A Fuel-Injector Pump

A Description of a Recently Patented Appliance for Use with Internal-Combustion Engines

This appliance resembles the ordinary sparking plug as used for motor-car engines, except that the diameter of its body is larger. The size is controlled by the cylinder capacity of the engine to which it is fitted, and is roughly about twice the size of the ordinary plug.

As in the case of the sparking plug, all the components are housed in a casing, the lower end of which is threaded, and screws into the cylinder head in precisely the same manner as the sparking plug, and is just as easily removed.

Component Parts

All parts can be removed from the casing in the space of half a minute or less.

The main moving parts of the appliance are as follow:

The valve needle and column (1) around which the various parts are assembled. The valve needle is loaded by means of a spiral compression spring (4) which is supported upon a collar provided somewhat lower than the centre of its length. By reducing the diameter of the needle column, a fuel space (3a.) is formed between it and the plunger of the pump (2) within which it is contained. The needle rests upon a countersunk seating in the bottom end of pump plunger which forms a nozzle for spraying the fuel into the cylinder.

In the fuel pump plunger (2) a seating is formed for the valve needle.

The pump barrel (5) houses the fuel pump plunger in its lower portion, while its upper portion contains a fuel regulator sleeve (3) provided with a collar or flange which supports a compression spring (8) (surrounding it) for its actuation.

This spring is compressed by a cap (11) which fits over it and which is threaded internally to screw over a stop formed on the pump barrel above the flange for the pump regulator collar (7).

The stroke of the fuel pump (2) is controlled or regulated by a collar (7) which fits over the outer casing, and over the flange on the pump barrel. Flange diameter is the same as that of outer casing.

The pump is actuated by a specially designed cam or stud (17) inserted in the piston casting of the engine with which it engages for a predetermined period of the stroke.

Fuel Regulator

The fuel regulator (3) consists of a sleeve turned to fit into the upper end of the pump barrel, and is provided with a flange and compression spring (8). Its lower extremity extends into the pump barrel for a short distance beyond the collar on the valve needle column. Its upper end is threaded internally to take the adjuster nut (9) for the needle compression spring (4), and externally to take a fuel-control-gear lock nut.

Pump Barrel and Plunger

The pump barrel is bored to take the pump plunger and fuel regulator sleeve, and is turned externally to fit inside the outer casing. The bore consists of three sections:

The lowermost is smaller and takes the bottom end of the pump plunger while the set-off between the sizes forms a terminal stop to the plunger traverse. The set-off between the centre and top portions forms a terminal stop for the travel of the fuel regulator sleeve.

The pump barrel and the casing, the lower end of which forms a gas-tight joint with the pump barrel.

The upper end of the casing bore terminates in a gland around the pump barrel which seals the fuel reservoir.Externally, the casing is flanged to seat on a gasket on the cylinder head, and the flange is bored through this flange to screw into the cylinder, while the diameter above the flange is reduced to save weight, and add to the appearance of the appliance.

Above this the diameter is increased and flat parallel faces are provided, for the use of a spanner, while on one side, between them, a hole communicating with the fuel reservoir is provided for the insertion of the fuel supply pipe (12).

Pump Adjustment

Above the flats, the same diameter of the casing continues to permit of a coarse left-hand female thread which engages a similar thread in the lower portion of the collar (7) for controlling the stroke of the pump.

As before stated, the upper end of this casing terminates in a gland. Equally spaced around the gland nut are four studs or pins (7a) which are screwed into its top face, and extend through holes in the broad flange on the pump barrel, thus preventing it turning with the collar.

As the collar is provided with a right-hand female thread upon its upper internal face, and a left-hand thread upon its lower internal face, any rotary movements imparted to it will result in an axial movement of the pump barrel, which will thus rise or fall according to the direction of rotation. A quarter turn of the collar in either direction will raise or lower the pump barrel the required distance.

The adjustment of the fuel regulator is secured in a somewhat similar manner, save that in this case the top of the regulator spring cap (11) forms a seat for two washers (13 and 14), the opposing faces of which are each provided with four ratchet teeth of exactly similar form and, as the upper portion of the cap is secured to the sleeve by a grub screw, while the lower one is free to rotate, any movement of the loose washer will increase or diminish the distance between the faces, thus lifting or lowering the sleeve. Rotation of the sleeve is prevented by a grub screw (16) in the bore of the pump barrel engaging in a longitudinal slot (16) cut in the sleeve.

Attachment for remote control of the fuel pump, and the fuel regulator is provided by drilled lugs attached to the revolving part of each gear. Fuel is supplied to the pump chamber through small holes (5a) drilled radially in the pump barrel at a point coinciding roughly with the flange at the lower extremity of the casing.

Method of Operation

The only contact between the moving parts of the engine and the injector pump is by means of the stud or cam (17), attached to the piston.

At this moment that the cam engages with the injector end of the pump plunger, fuel commences to be injected through the jet into the cylinder, and this injection
How to Make Bellows

Methods of Making Bellows of Varying Shapes and Sizes

Bellows can be made from paper, stiff cloth, leather or imitation leather. Leather is undoubtedly to be preferred where cost is not a consideration. However, stiff cloth or even good quality paper can give good service. It is possible to make bellows of practically any shape, square, oblong or any straight sided figure provided it has an equal number of sides. Thus nearly round bellows could be made by increasing the number of sides as far as practicable. Straight-sided bellows (where the peaks of the folds on all the sides are in a straight line, whether the bellows are square or tapered), can be made from a single sheet of paper. Where a curve is wanted, or a change of taper required, more than one piece of material must be used, usually four, but this varies. The length of the flat sheet from which the bellows are to be made requires to be two and a half times the length of the extended bellows. They can be extended further, but the folds may be displaced, and will fail to collapse later.

Square Bellows

Fig. 1 illustrates a square bellows, having internal dimensions of X by Y, and the preliminary layout of the sheet is shown in Fig. 2. The spaces "A" are equal to the width of the lines crossing them, which are equal to the depth of one fold. The fold-depth can really be anything, but the graph, Fig. 3, can be used for finding a convenient figure. The space "B" at the end of the sheet is a flap for securing to the other edge to form the first tubular construction of the bellows, and can be any convenient size according to the material used, and is usually between \( \frac{1}{2} \) in. and \( \frac{1}{4} \) in. in width. These marking lines should be made lightly to avoid scoring where it will not be required. Having laid out the whole sheet, score in the diagonal lines and certain of the straight lines with a blunt edged tool, as shown in Fig. 4, the scored lines being shown heavily. Then turn the sheet over and score the remaining lines, which are only straight ones and although that side is not marked, the positions where the scores have to be made can be seen by the score marks already made on the other side. The second series of score marks are indicated in Fig. 4, by the faint lines. The side of the sheet shown in Fig. 4, is the inside of the bellows, and this should be remembered when making-up. The securing flap "B" must also be scored to follow on, so that its "vees" fit the "vees" at the other edge. The flap can now be pasted up and the edges brought together, the sheet forming a tube, no effort being made at this stage to form the folds.

Manipulating the Folds

When the paste has set, stand the bellows on one end and with the fingers manipulate the folds into position. Press the first scored lines inwards at the same time, flatten the diagonal scores at each end. Then do the next lower pair, on the adjacent sides, and so on down the tube. When the last folds have been done, place a piece of wood on the top and press downwards or leave for an hour or two under a heavy weight. The end folds of the bellows instead of being creased diagonally can be folded up square as shown at the top of Fig. 1, this allowing the bellows to fit either over or inside a framework.

Tapered Bellows require a layout made on the same principles, but each side must be marked out individually from a line drawn down the centre of each side. The construction is shown in Fig. 5 and the completed bellows in Fig. 6. It should be noted that the strips "A" which form the corners of the bellows are parallel and all the diagonal creases are of the same angle, i.e. 45 degrees. Under the load exerted by its spring, and the fuel space (3a) in the pump chamber is filled with a fresh charge which is sucked from the annular fuel space around the pump barrel (6a) through the radial holes (2a) in the pump plunger.

As the pressure on the fuel increases, the injector needle valve overcomes the spring holes (2a) in the pump plunger. The upward motion of the pump plunger travels its full distance or that of any of its parts —

1. Length of stroke of pump plunger
2. Quantity of the fuel charge (limit as above)
3. Spring pressures.
Copper Steel.—A variety of steel introduced in 1883 by Mr. Alexander Dick, who named it with the Greek letter "D" (Delta), to associate it with his own surname. Copper steel is having an increasing use in the manufacture of such articles as steel sheets, smoke-boxes, and ashpan plates of locomotives. It possesses much of the desired iron article in a bath containing a dilute solution of iron phosphate in dilute phosphoric acid, the bath being heated to near its boiling point. This way, an extremely thin coating of grey iron phosphate is formed on the surface of the iron article. This coating is very hard and tenacious, and it very satisfactorily protects the underlying metal from the ravages of rust and corrosion. The process is one which at the present day is much used in the bicycle and allied trades. Delta Metal.—A very similar alloy to Munts's metal. It is, in reality, a variety of brass which has a high tensile strength. It can be forged and rolled and it is much used for ship's propellers. It is resistant to corrosion.

Typical composition : copper, 55% ; zinc, 43.5% ; iron, 1% ; lead, 4% ; phosphorus, 1%

Delta Metal was introduced in 1883 by Mr. Alexander Dick, who named it with the Greek letter "D" (Delta), to associate it with his own surname.

Dental Amalgams.—Dental amalgams and alloys vary enormously in composition and many of them are more or less secret, in nature. Amalgams of tin, mercury, and cadmium have long been used in dentistry. These amalgams become plastic on kneading, and set again without contraction. A copper amalgam is sometimes used in dentistry.

An amalgam of silver, tin, gold, and mercury is at times used as a metallic "filling" for teeth. Other dental amalgams contain platinum and other rare metals combined with mercury.

Duralum.—One of the most important of the light aluminium alloys. It possesses the remarkable property of slowly increasing in tensile strength in the course of four or five days from 18 to 26 tons per sq. in. after it has been heated for half an hour to 500°C. and then quenched in water.

The average composition of duralum is : aluminium, 95% ; copper, 4% ; magnesium, 5%.

The alloy, on account of its strength, is much used for aircraft work.

(From the French dur, hard.)

Dural.—A type of silicon steel containing from 14% to 14.5% of silicon and from 2% to 3% of carbon, together with very small amounts of manganese and phosphorus. Its tensile strength is only three-quarters that of cast iron, but it has a very high resistance to acids, for which reason it is employed for making into acid containers and similar articles.

Dwi-manganese.—This is the name given by the chemist, Mendeleeff, for the metal, Rhenium, the discovery of which he predicted.

"Dwi" is a Sanskrit numeral, meaning "the second after," and, in this connection, it refers to the position of Rhenium in Mendeleeff's Periodic Table of Elements.

Dysprosium.—Metallic element. Chemical symbol, Dy ; At. No. 66; At. Wt. 162.5.

A rare metal discovered in 1886 by Lecoq de Boisbaudran in certain rare earth minerals, and by him given the name "dysprosium," from the Greek word dysprositos, "difficult of access," in allusion to the difficulty of extracting the metal and its compounds in the pure state. The metal has a light greyish colour, but it is, of course, a mere chemical rarity.

Electric Amalgam.—Name given to a class of amalgams which are employed in frictional electric machines for assisting the production of the generated electricity. There are several different varieties of electric amalgam, although they are usually tin or zinc amalgams.
Electrolytic Copper.—This is copper of the highest commercial purity which has been refined by a process of electrolysis. It contains about 99.86% of copper. It is essential to employ copper of this purity for most electrical purposes, for the presence of any impurities often considerably reduces the electrical conductivity of the metal.

Electron Alloys.—Name given to a group of electrolytically refined copper alloys. Refinement is obtained by a process of electrolysis. A typical electron alloy has the composition: magnesium, 46%; copper, 50%; zinc, 4%; aluminium,.5 to 1%.

Emerald Brass.—A hard brass alloy of a rich golden colour. Gives a good colour when lacquered and is much used for rich golden colour. Gives a good colour when lacquered, etc. A typical electron alloy has the composition: magnesium, 50%; copper, 5%; zinc, 4%; aluminium, .5 to 1%.

Amalgam, Bottger’s Amalgam. A typical electron alloy has the composition: magnesium, 50%; copper, 5%; zinc, 4%; aluminium, .5 to 1%.

Fusible Alloys.—Name given to a group of alloys which melt at a lower temperature than the constituent metals. They are: Nickel, Cobalt Copper. Manganese Chromium Titanium Vanadium Tungsten Aluminium Silicon Molybdenum Uranium Zirconium Beryllium

File Alloys.—Many copper-tin alloys are employed for the preparation of such files (to distinguish them from steel files) being designated composition files. A typical file alloy has the composition: copper, 95%; tin, 5%; iron, 10%; lead, 7.6%.

Genetite.—A synthetic bearing metal consisting of graphite impregnated with metallic gallium. Developed in America by the General Electric Company. It has a low tensile strength (3 tons per sq. in.) but the material is very porous and will absorb about 3% of its weight of oil, which is gradually exuded when the bearing is in use, thus maintaining the latter in a satisfactorily lubricated condition.

Galvanised Iron.—Iron which has been covered with a protective layer of zinc to prevent it from rusting. In the galvanised process, the steel is dipped with acid or by means of a fine sandblast, and afterwards dipped in molten zinc. In another process, a zinc coating is deposited electrolytically. In the presence of water a galvanic action is set up between the zinc and the underlying iron, whereby the zinc very slowly dissolves, and no rusting of the iron occurs so long as any of the surface zinc remains. The term "galvanised" is, of course, derived from Luigi Galvani, the electrician of Bologna (1737-1798).

See Surgical Metal.

Gold.—Metallic element. Chemical symbol, Ge; At. No. 32; At. Wt. 197; M. 986°C; Sp. Grav. 19.3. Discovered in 1850 by C. Winkler, in argyrodite, a silver ore, which he found to contain about 7% of a new element, subsequently termed by him "Germanium," from Germany, the Latin name for his country.

Germanium.—Metallic element. Chemical symbol, Ge; At. No. 32; At. Wt. 72; M. 986°C; Sp. Grav. 5.47. Discovered in 1886 by W. Ramsay, in argyrodite, a silver ore, which he found to contain about 7% of a new element, subsequently termed by him "Germanium," from Germany, the Latin name for his country.

Germanium is a metal which is related to tin, and the one holds its position in the periodical table of the other. It is greyish-white, lustrous, and brittle, and, in ordinary air, is unattacked.

Gold.—Metallic element. Chemical symbol, Ge; At. No. 32; At. Wt. 197; M. 1,062°C; B.P. 3,530°C; Sp. Grav. 10.5; Sp. Ht. 0.30; Coef. Exp. 0.74; Dens. 19.3; Elec. Cond. at 0°C (Mercury -14) 14.4.

Gold is one of the precious metals, having been known from the earliest times. The alchemists called it sol (the sun) and represented it by the circle, the symbol of perfection, for, to them, gold was the most perfect of all metals. Gold is usually found in the metallic state, but is widely distributed in Nature. Sea-water contains 3 grams of gold per ton, and granite, on the average, contains .37 parts of gold per million. Gold is a yellow metal, being the most malleable and ductile of all metals. Gold sheets as thin as 250,000 parts of an inch can be produced. Even thin sheets, gold transmits green light, and the vapour of boiling gold is also green.

Gold is not acted upon by air or oxygen, or by most chemical reagents. Hence it forms one of a group of Noble metals which remain unattacked by most chemical reagents. It combines with chlorine or bromine to form single acid which will dissolve gold. The metal is, of course, dissolved by aqua regia, a mixture of strong nitric and hydrochloric acids.
Making Bromine

What is the laboratory method for the preparation of bromine? — G. S. (Bexley, E.3).

If you have the necessary apparatus, you will not find it a difficult matter to prepare a quantity of bromine.

All you require is a glass retort, a tripod on which to rest it, and a retort stand, together with a bunsen burner or a spirit-lamp. The materials required are potassium bromide, manganese dioxide and concentrated sulphuric acid.

Powder up the potassium bromide crystals and intimately mix them with one-fifth of their weight of manganese dioxide. Place this mixture into the retort and just cover the mixture with concentrated sulphuric acid.

The glass receiver must be kept cool by being immersed in water (or, preferably, in iced water). When the material in the retort is very gently heated, bromine will be liberated and will distil over as a heavy, red, pungent-smelling vapour which will condense on the cold liquid in the receiver.

The liquid bromine is very volatile and it readily attacks corks and other materials. It should be kept in a glass-stoppered bottle, the stopper of which is very lightly smeared with vaseline.

The above paste is then smeared over the glass by means of a rubber stamp, since the sulphuric acid present in the paste would completely destroy the rubber.

Concentrated Heat

Is it possible to concentrate the heat from a radiant heat bulb or other electrical apparatus by means of a lens in the same manner as the sun's rays can be concentrated? Also, if heat bulbs were made on a larger scale, would the rays emitted have a longer range? — D. H. (Westcliff-on-Sea).

To a certain extent, the heat content of any luminary may be concentrated by means of an ordinary lens, as witnessed, for instance, the well-known "burning glass." By means of such a device, fire might be set on fire with the sun's rays.

Glass, however, is not perfectly transparent to heat rays. Hence, if one desires to transmit and concentrate heat rays by means of a lens system, it becomes necessary to use a lens made of transparent material, which lenses, although they are commercially available in small sizes, are very expensive and not very durable.

Polished metal surfaces have the property of reflecting heat. It is for this reason that the heat of the radiator element is usually concentrated onto a roughly parallel beam by means of a specially curved reflector of polished metal placed behind the radiator element.

If the radiant element were increased in size, the amount of heat radiated would necessarily be increased, and would, therefore, be felt at a greater distance. The size of the radiant element, however, would not, in ordinary circumstances, influence the type of heat-ray radiated; it would merely modify the intensity of the ray, a larger radiant giving the ray more energy and thereby enabling it to travel to a greater distance.

Jointless Flooring Composition

A model experimenter with a jointless flooring composition, monoplane, floors, and have been advised to use sawdust, wood flour, magnesite, asbestos and a solution of magnesium chloride. Will you kindly inform me as to the right quantities to use of each substance and in what order to mix? — K. S. (South Africa).

A "Asbestos" and "Asbestine" are trade names, but, unfortunately, we have not been able to trace the makers of these products. You may be able to obtain the lower grades of that material, that they are identical, and that they consist of some type of natural asbestos flour, such as may be obtained from Messrs. Thomas Hill-Jones, Bow, London, E.3.

The jointless flooring composition you name is quite good, and, within reasonable limits, you may proportion the various ingredients just as you require them. If necessary, you can omit the asbestine (or asbestos) and substitute for it fine sand (passing 1/16th mesh). A suggested formula using the ingredients which you name is the following:

**Magnetic (Magnesium carb.)** 100 parts

**Wood Flour** 35

**Asbestos (fine sand)** 60-70

The above to be mixed intimately together and then worked up like mortar, with a fairly strong solution of magnesium chloride.

The above composition will take about three days to dry out properly and, on setting, it will expand very slightly. In making up the composition, a reasonable mixture of finer and coarser particles should be aimed at, the finer particles of the ingredients, or aggregate, imparting a smooth surface to the composition, while the coarser particles giving strength to the mixture.

Chemicals for Respirators

What chemical is suitable for use in a respirator as a protection against sulphur dioxide? Is there any choice of chemicals for this purpose? — E. C. (Essex). A mixture of equal parts of soda lime and activated carbon will form the best filtering medium for the removal of sulphur dioxide. These materials are cheap and can be obtained from any wholesale chemist, for instance, Messrs. May & Baker, Ltd.,
Dagenham, or Meaus, Harrington Brothers, Ltd., Oliver’s Yard, City Road, Finsbury, London, N.

Lead peroxide and, also, sodium peroxide are two materials which powerfully absorb sulphur dioxide. In most instances, however, these cannot be used for commutator work, since they become hot in consequence of their chemical action on the gas.

**Vitamins in Foodstuffs**

Can you tell me how to test for vitamins in food and how to find in what quantities they are present? Is it possible to obtain a chart showing the calorific value of various foodstuffs?—A. L. (S.W.17).

**There** is absolutely no simple chemical test for the presence of the various vitamins in foodstuffs. The few tests which are available are extremely complicated and lengthy ones, and, moreover, they do not usually allow the actual amounts of the vitamins to be estimated, since vitamins exist in such small quantities in foodstuffs.

If, however, you will write to the British Drughouses, Ltd., Graham Street, City Road, N.1., or to Messrs. Boots Pure Drug Houses, Ltd., Graham Street, City Road, N.1., or to Messrs. Harrington Brothers, Ltd., Oliver’s Yard, City Road, Finsbury, L., or to Messrs. Harrington Brothers, Ltd., Dagenham, or to Messrs. Harrington Brothers, Ltd., W.C.2.

If you consult almost any textbook of food chemistry in your local library, you will be able to obtain abundant information on the subject of vitamin tests.

**What is Light?**

Is light an electro-magnetic radiation? If so, is it possible to collect and amplify after the manner of a radio-frequency amplifier? Is it possible to measure the frequency of light (say sunlight)? If it were possible to amplify light in the above manner what sort of reproducer would be necessary?—R. J. L. (Lisbellaw, N.I.).

**Light** is an electro-magnetic radiation, according to most theories, a sort of invisible vibratory energy transmitted through the medium of space. Unlike the wireless radiation of longer wavelength, it is, however, not possible to light by any direct electrical means, although it is very possible that at some future time, this feat may be accomplished satisfactorily.

To amplify light in the manner which you infer would necessitate the invention of some means of transforming the short wavelengths of light into the long wavelengths of ordinary electric (wireless) radiations. Such "converted light" energy would be amplified by means of a type of radio-frequency amplifier and then reconstructed back into light.

The problem is a huge one, and, very likely, it will not be solved in our time.

There are several methods of ascertaining the wavelength and frequency of light, all of which are rather complicated and difficult to explain briefly. Here, however, is one such method.

When a beam of sunlight is made to fall upon a "diffraction grating," which is a ruled metallic surface, the light beam is "diffracted " or spread out. The diffracted light rays may be brought to a focus by a lens, and the angles of their diffraction in a special instrument designed for this purpose, we can calculate the wavelength of the light in accordance with the following mathematical equation:

$$\sin \theta = \frac{\lambda}{d}$$

where

* $\lambda$ = wave length of light.
* $d$ = average distance between the scratches or ruling of the diffraction grating.

From the wavelength of the light, its frequency (i.e., number of vibrations per second) is calculated by means of another formula.

As you will now realise, the whole subject is a highly technical one, and for further elucidations of it we must refer you to any advanced textbook of physics or optics.

**Testing Linseed Oil**

From time to time I do a fair amount of indoor and outdoor painting about my home. I use various grades of paints, but some of these do not dry properly, in fact, they remain more or less sticky. I have come to the conclusion that this is due to the quality of linseed oil used in their manufacture. I would be glad if you could give me some information on the purity of linseed oil, so that I could decide beforehand of its suitability or otherwise for paint work. Many cheap paints are adulterated with "white spirit," a petroleum product, which, of course, does not harden like linseed oil or turpentine, and hence results in the paint remaining permanently sticky. Unfortunately, however, there is no simple test for its presence in already made-up paint.

A good test, however, for the purity of raw linseed oil is to rub a small film of it on to a sheet of glass. On holding this to the nose, there should be no odour of paraffin oil; also, the film of oil should harden within a few days.

If you have been making up your own paint with linseed oil, it is quite possible that the failure of your paint to dry out properly is due to your not having incorporated any solvent "drier" with the paint. Unfortunately, however, for the purity of linseed oil, so that I could decide beforehand of its suitability or otherwise for paint work. Many cheap paints are adulterated with "white spirit," a petroleum product, which, of course, does not harden like linseed oil or turpentine, and hence results in the paint remaining permanently sticky. Unfortunately, however, there is no simple test for its presence in already made-up paint.

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machine. This solution, which is not caustic, will loosen all the caked dirt on the metal surfaces, so that it can be washed away readily with fresh water.
Use plenty of rinsing mops, and then carefully wipe the surface of the machine dry.

For subsequent polishing, you would be advised to use a precipitated chalk made into a paste with benzine. This is applied to the metal surfaces, allowed to dry on, and then vigorously rubbed away with a fairly stiff brush.

Do not use an acid, alkali or sandpaper for the cleaning of your cash register, for such materials will not do the job properly, and moreover, they will cause trouble if they get into the interior of the machine.

For an instruction and other booklets dealing with the maintenance of your cash register you should apply to The National Cash Register Company, Ltd., 206-216, Marylebone Road, London, N.W.1.

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Will He Ever Wake Up?

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